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(54) **SURGICAL DEVICE**

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See application file for complete search history.

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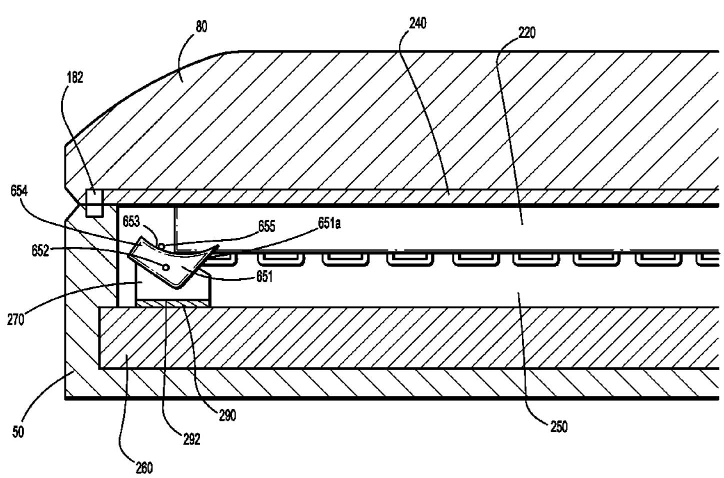
(57) **ABSTRACT**

A surgical device includes a first jaw and a second jaw disposed in opposed correspondence with the first jaw. The second jaw is mechanically coupled to the first jaw at a proximal end opposite a distal end. A cutting element is disposed within the second jaw, and a first driver is configured to move the cutting element proximally from the distal end toward the proximal end of the second jaw to cut a section of tissue disposed between the first and second jaws.

20 Claims, 23 Drawing Sheets



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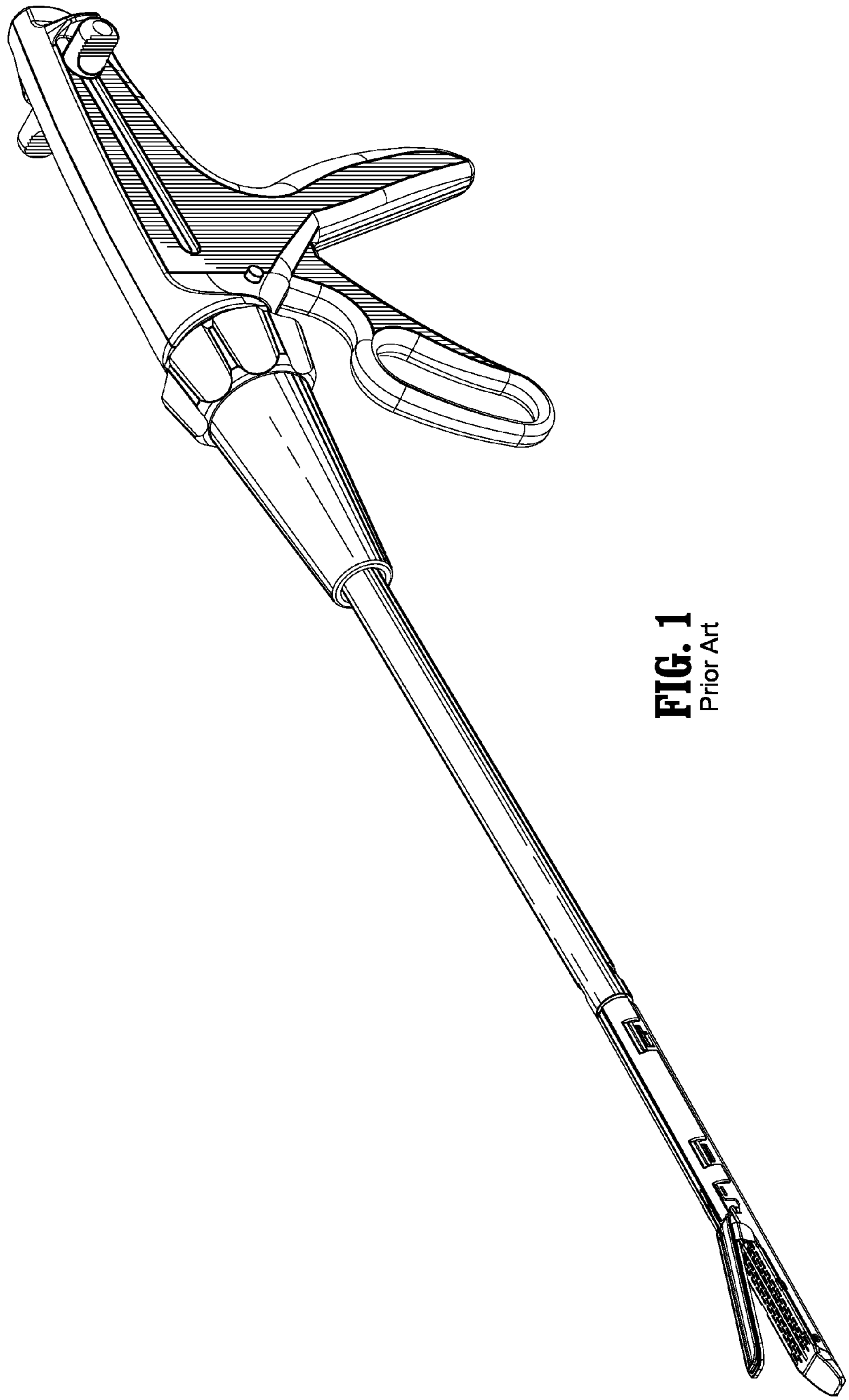

FIG. 1
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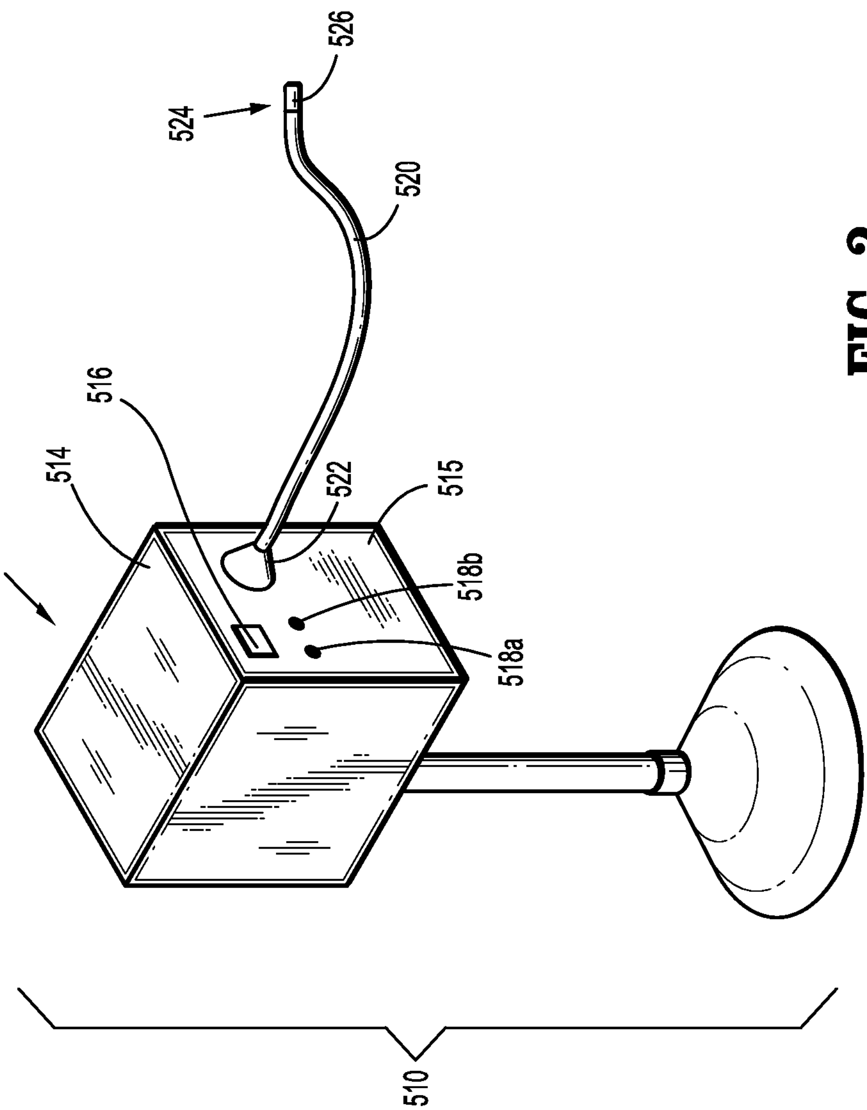

FIG. 2

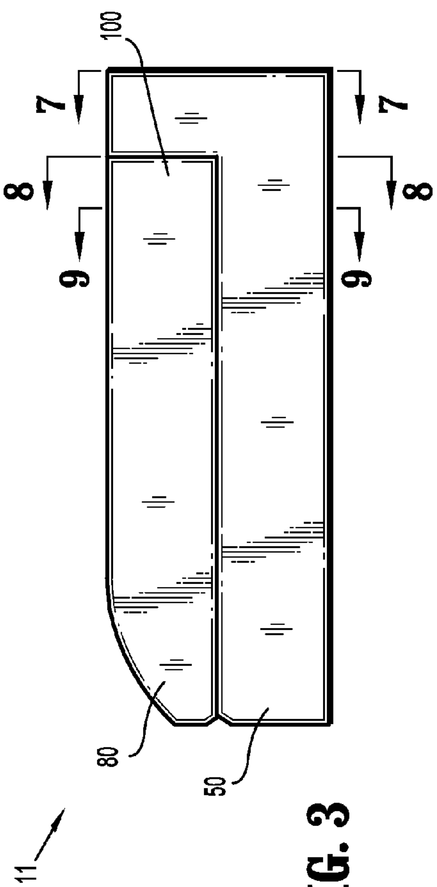

FIG. 3

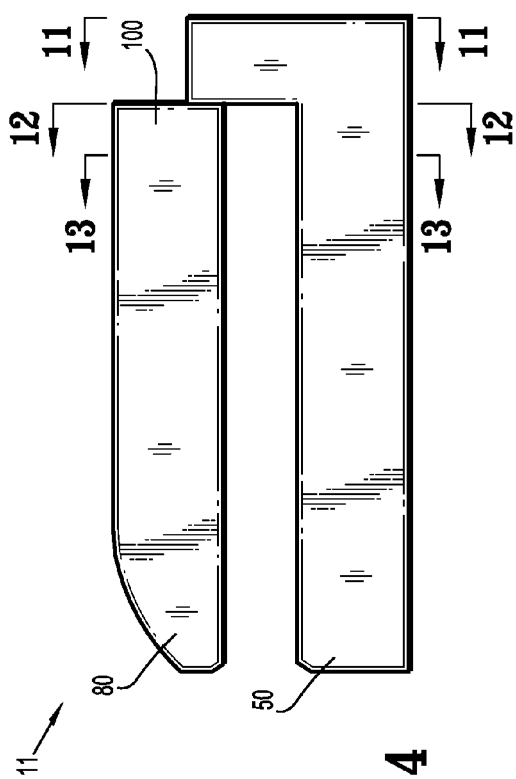

FIG. 4

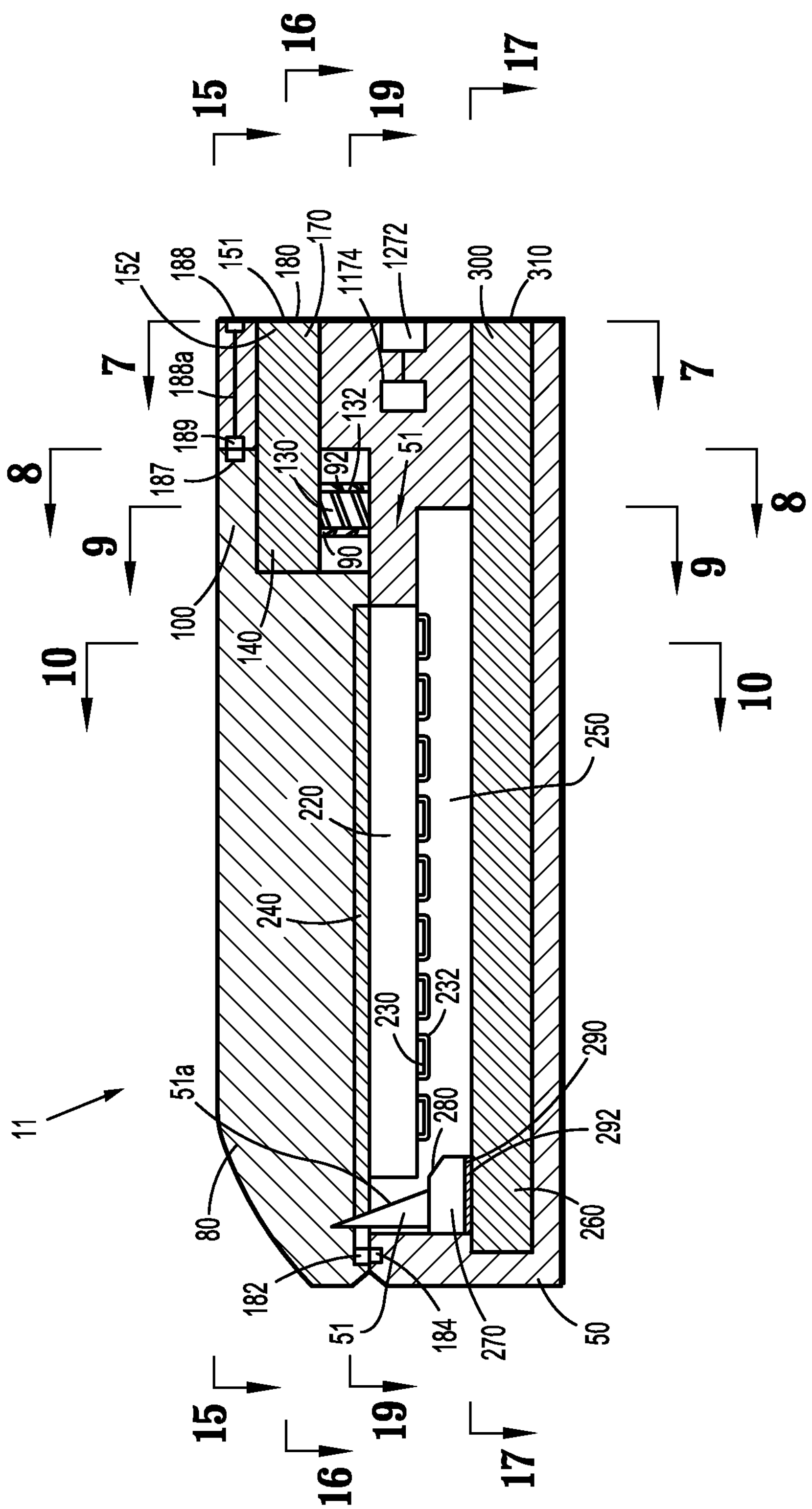
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FIG. 5

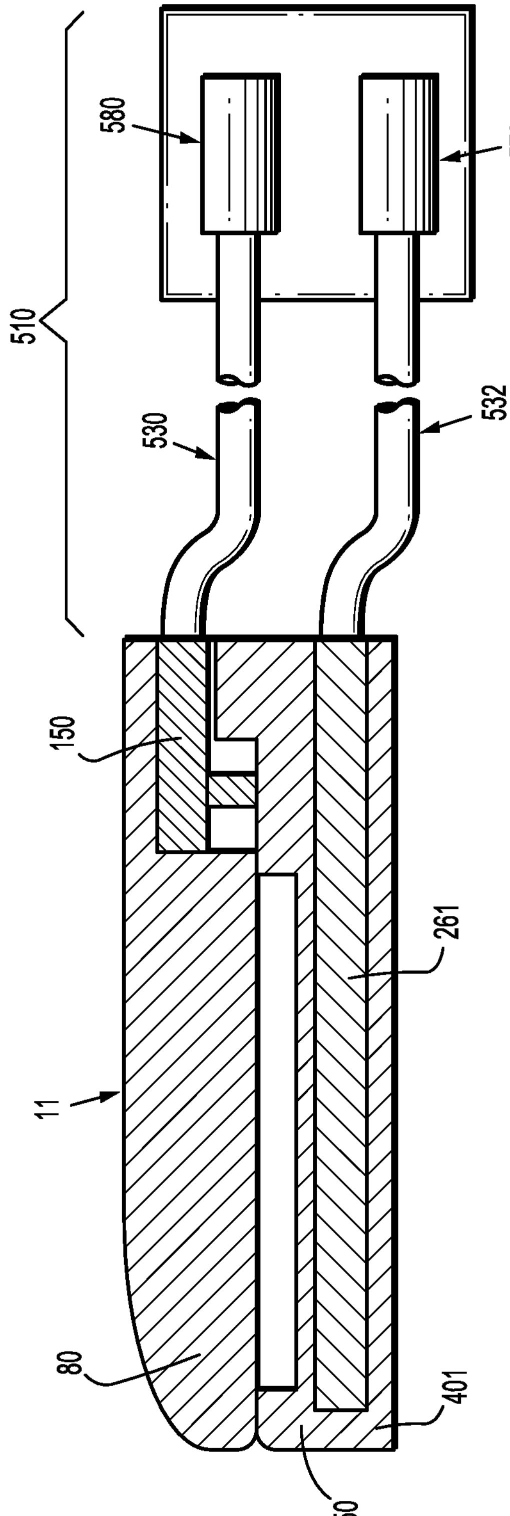

FIG. 5A

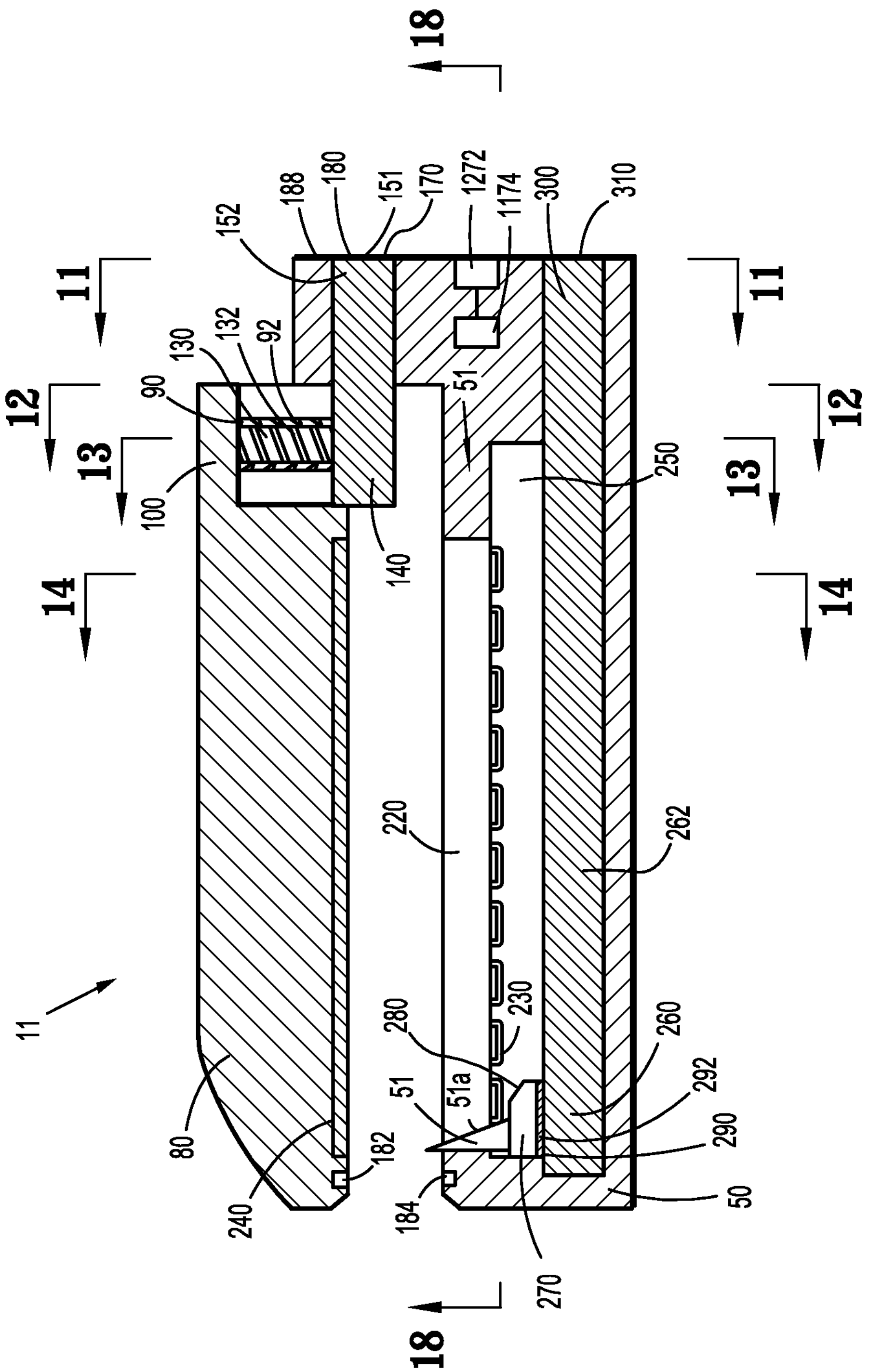
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FIG. 6

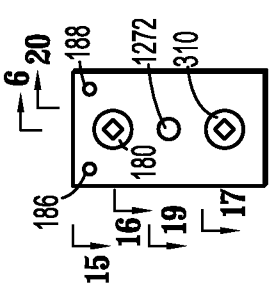

FIG. 7

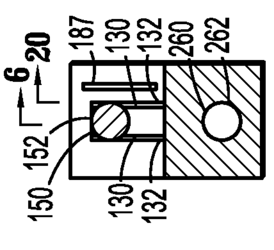

FIG. 8

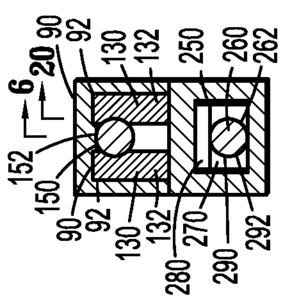

FIG. 9

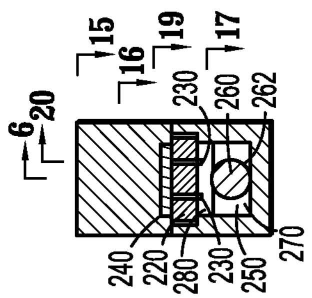

FIG. 10

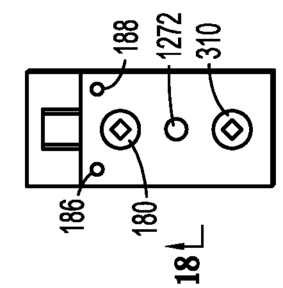

FIG. 11

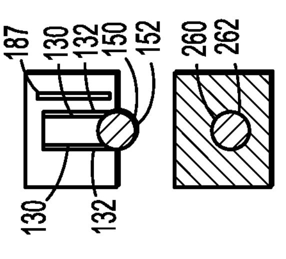

FIG. 12

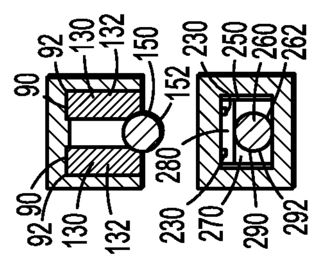

FIG. 13

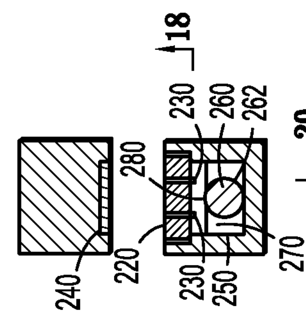

FIG. 14

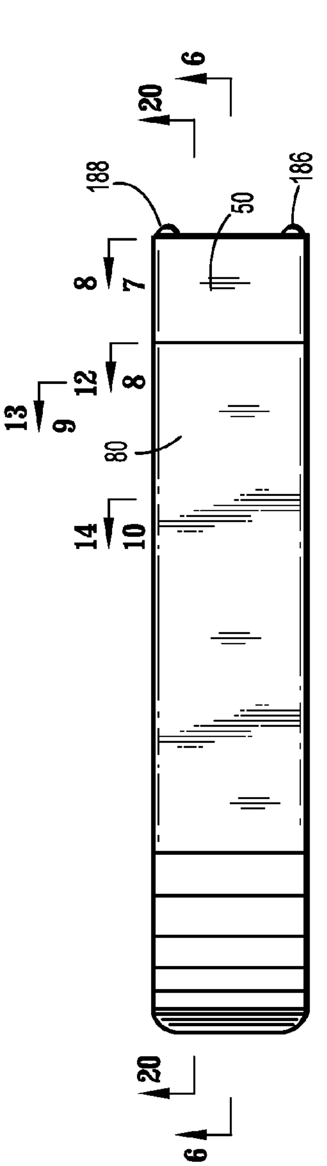

FIG. 15

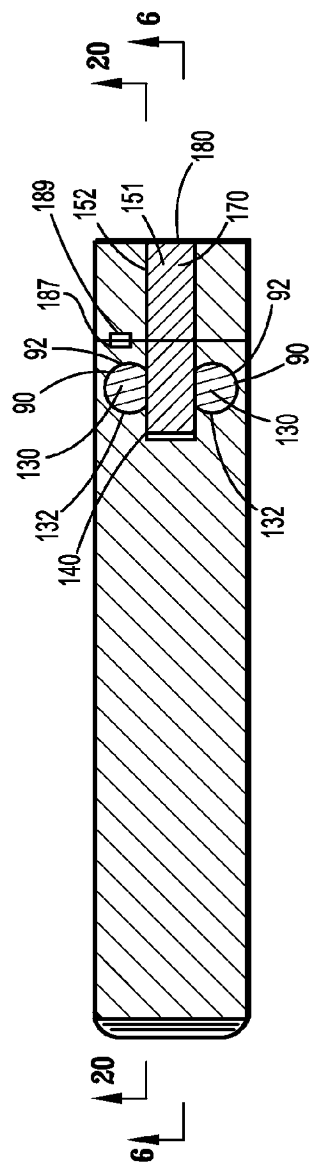

FIG. 16

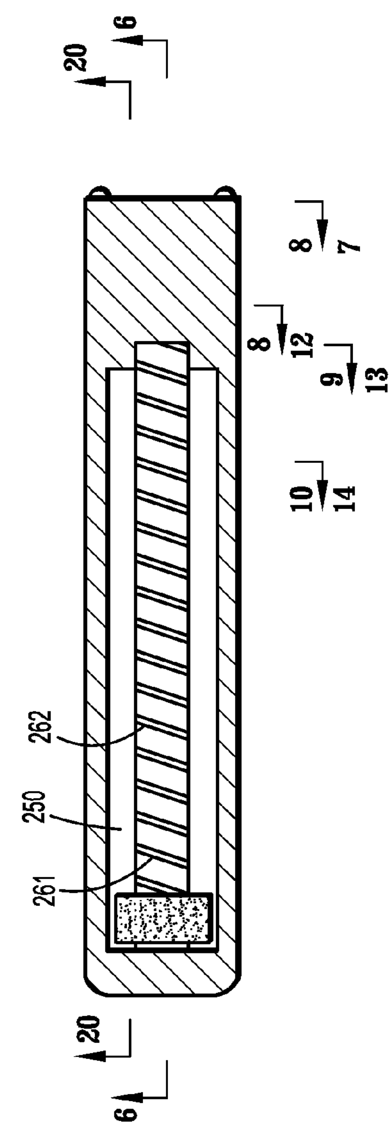

FIG. 17

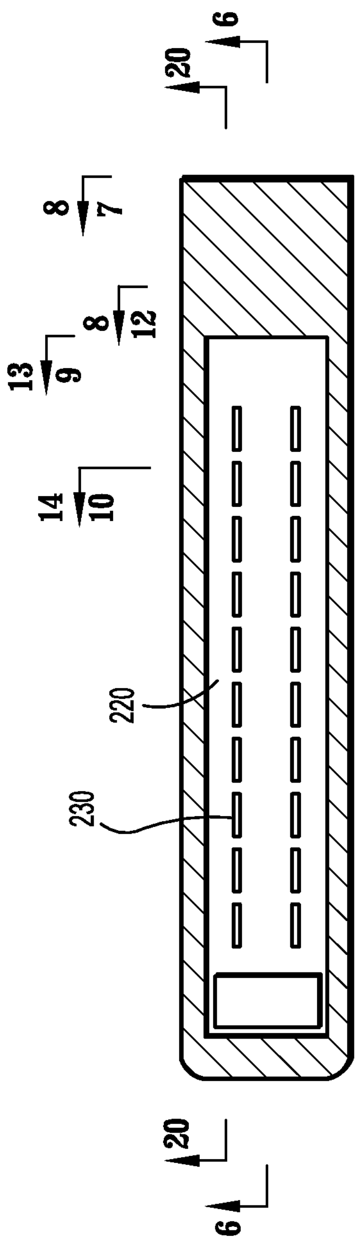

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FIG. 18

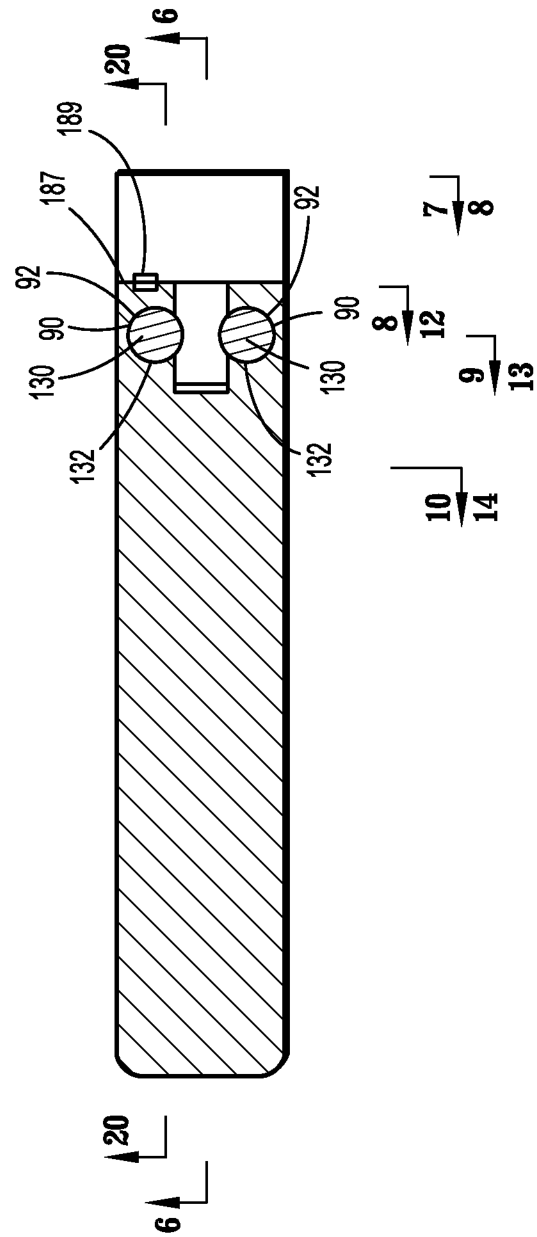

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FIG. 19

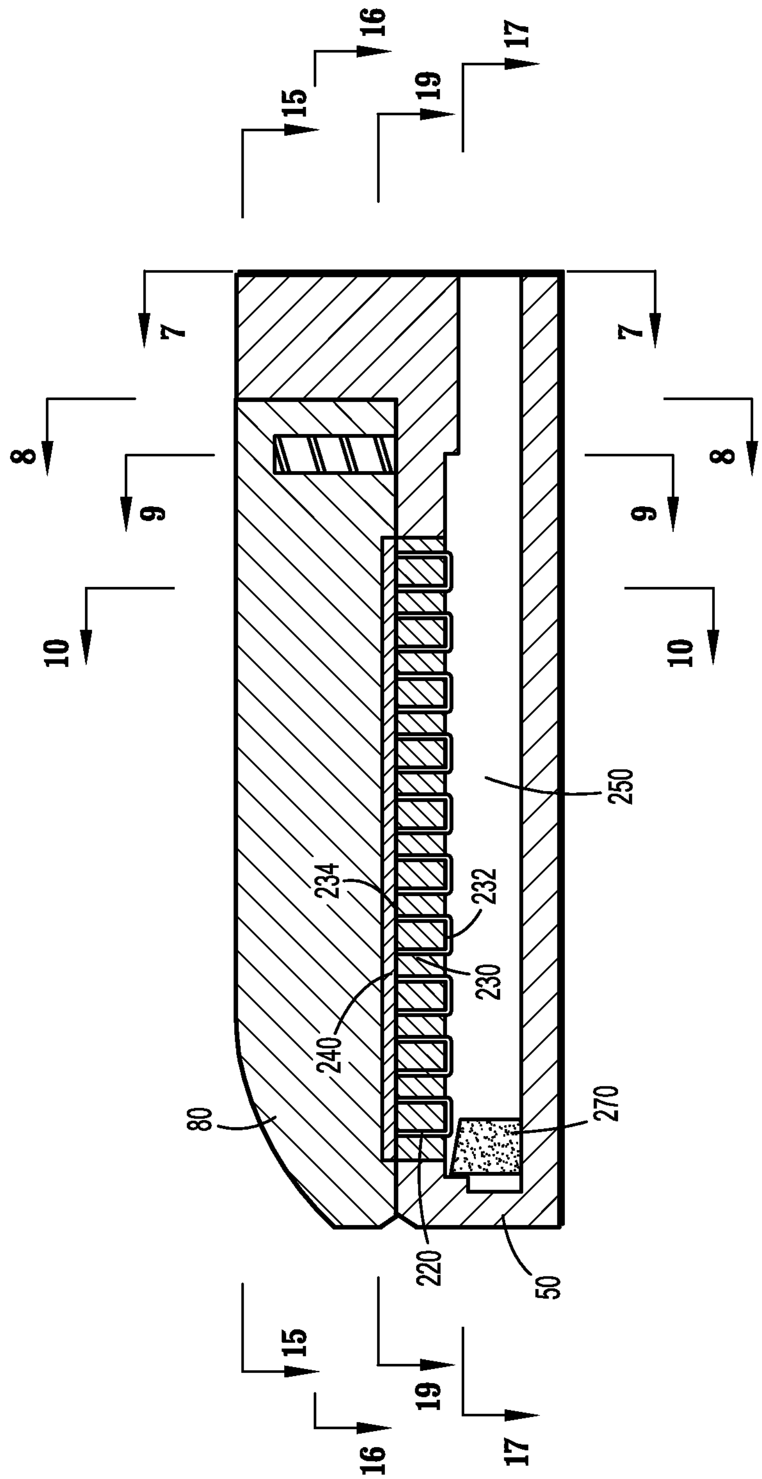
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FIG. 20

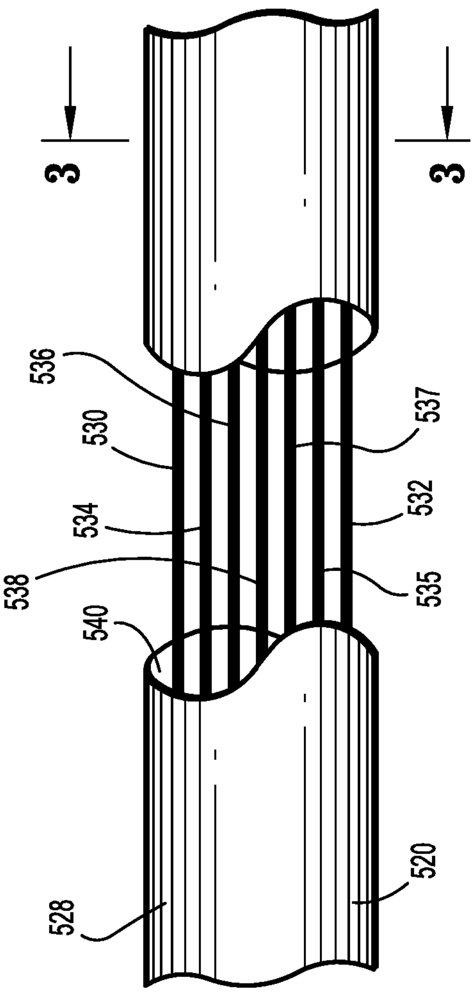


FIG. 21

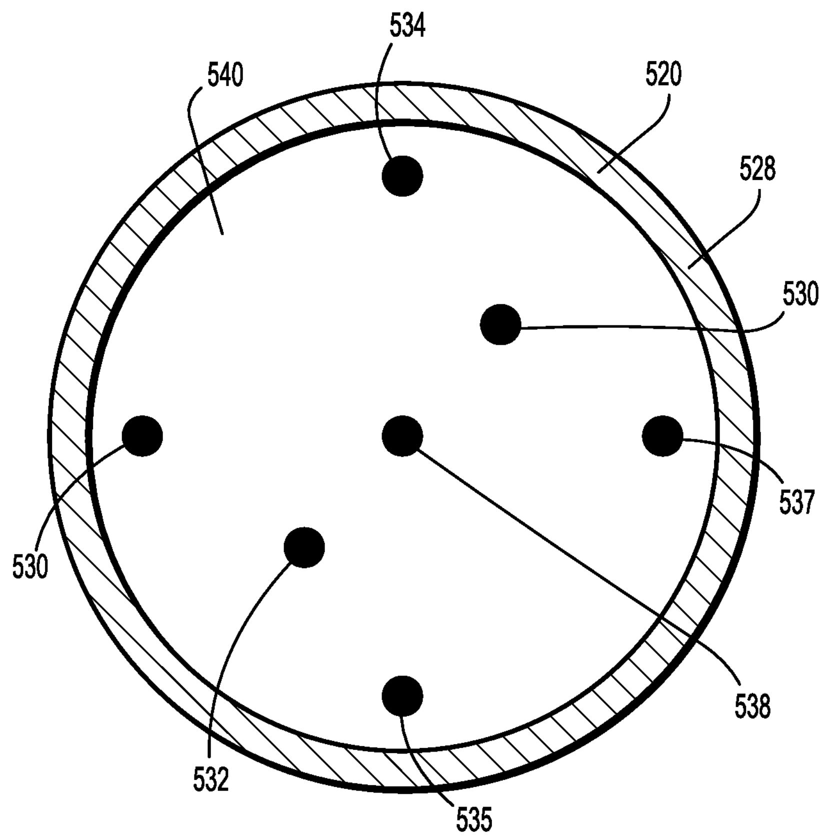


FIG. 22

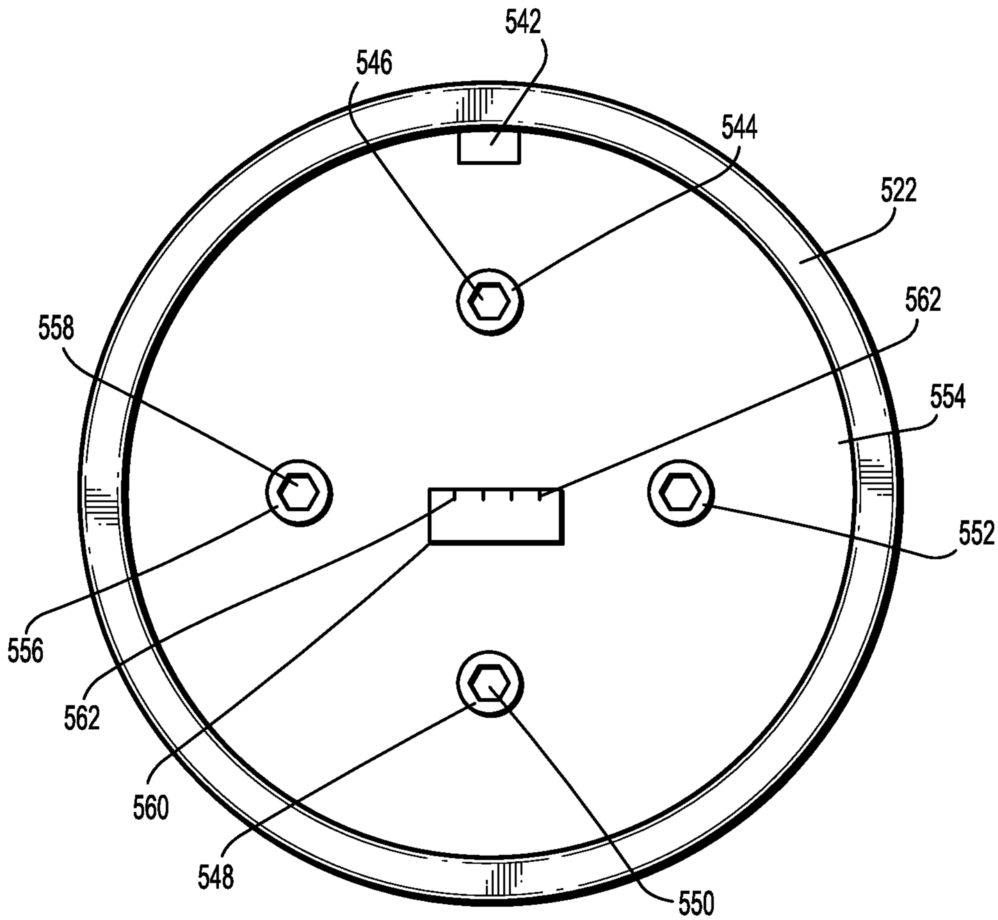


FIG. 23

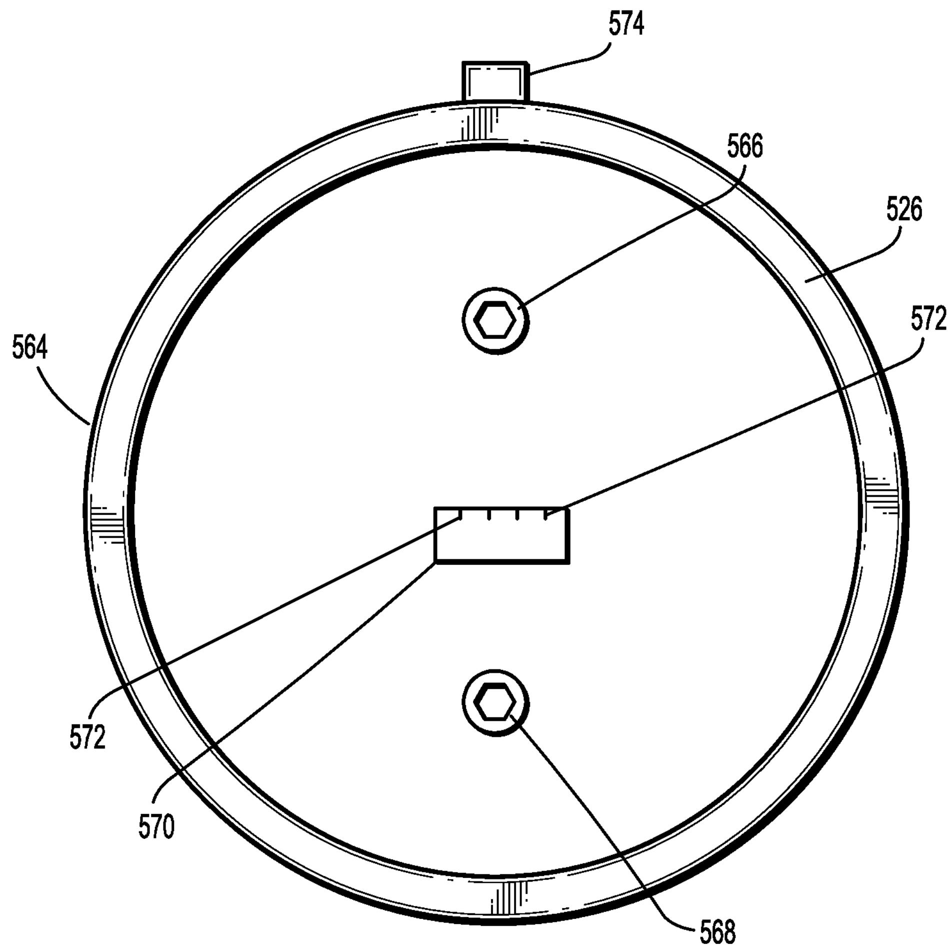
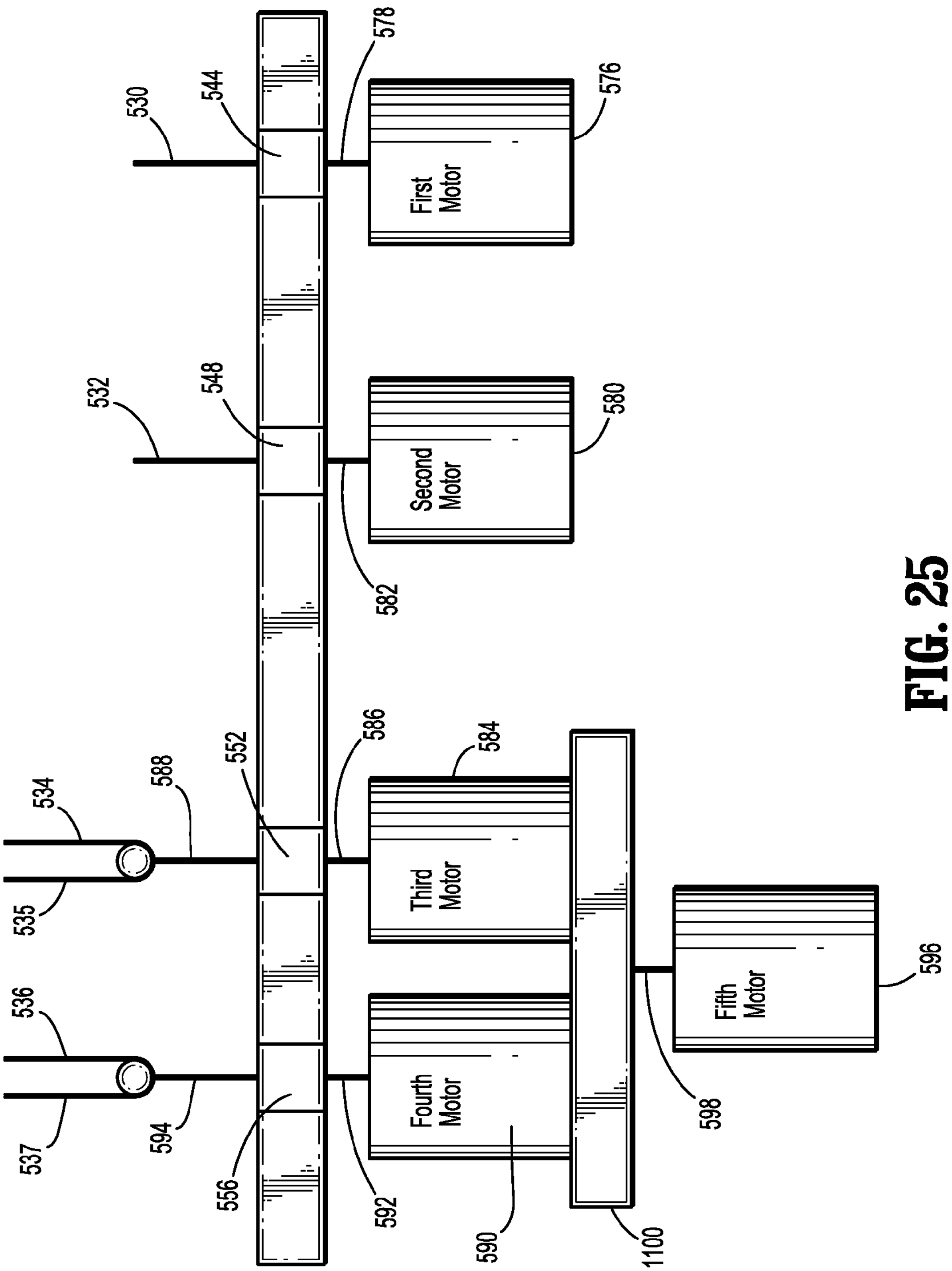


FIG. 24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Second Motor
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584
Third Motor
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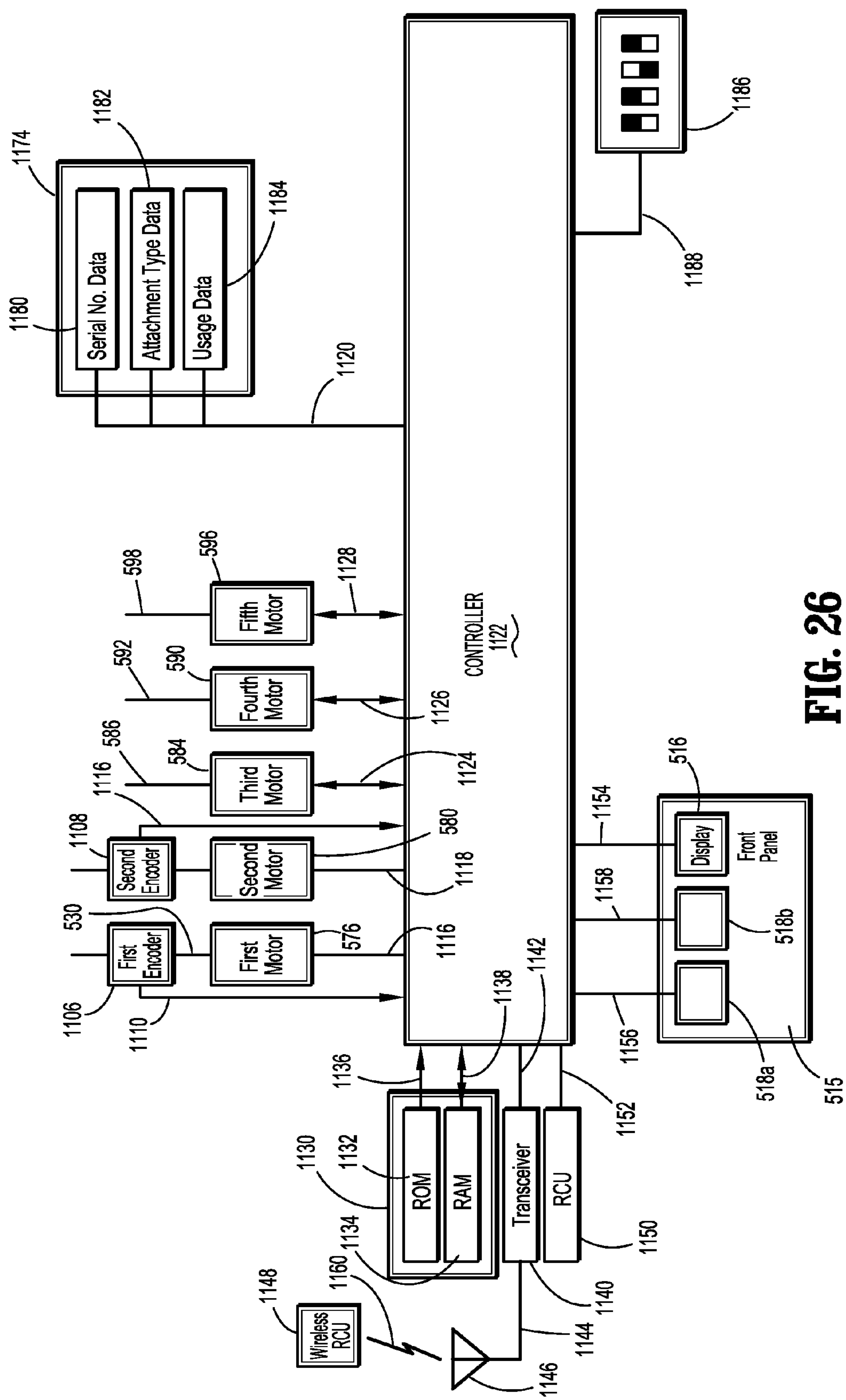
537
594
556
592
Fourth Motor
590
1100
598
Fifth Motor
596

FIG. 25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Third Motor
Second Motor
First Motor
Second Encoder
First Encoder
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596
592
590
586
584
1128
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1124
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576
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RCU
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FIG. 26

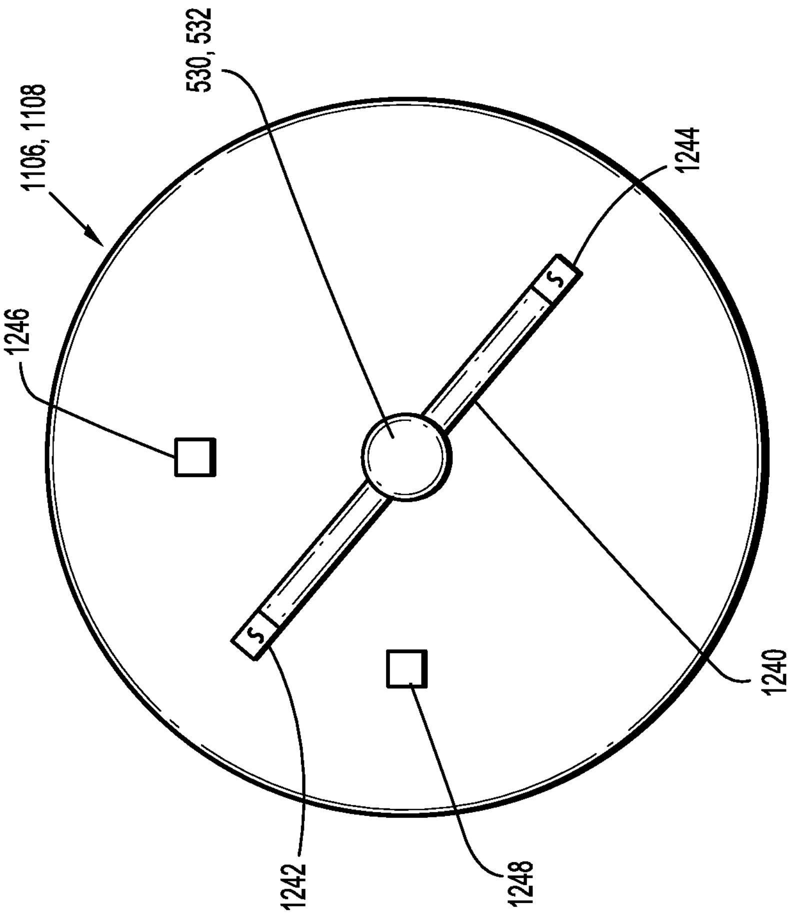

FIG. 27

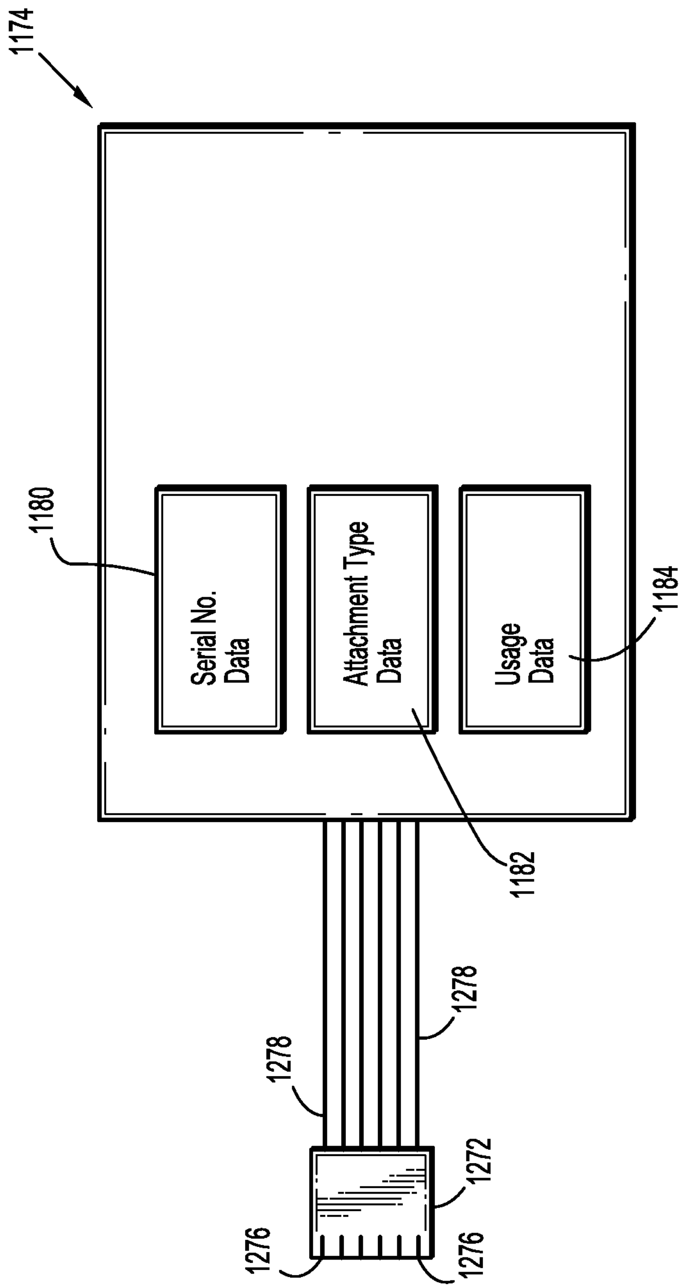
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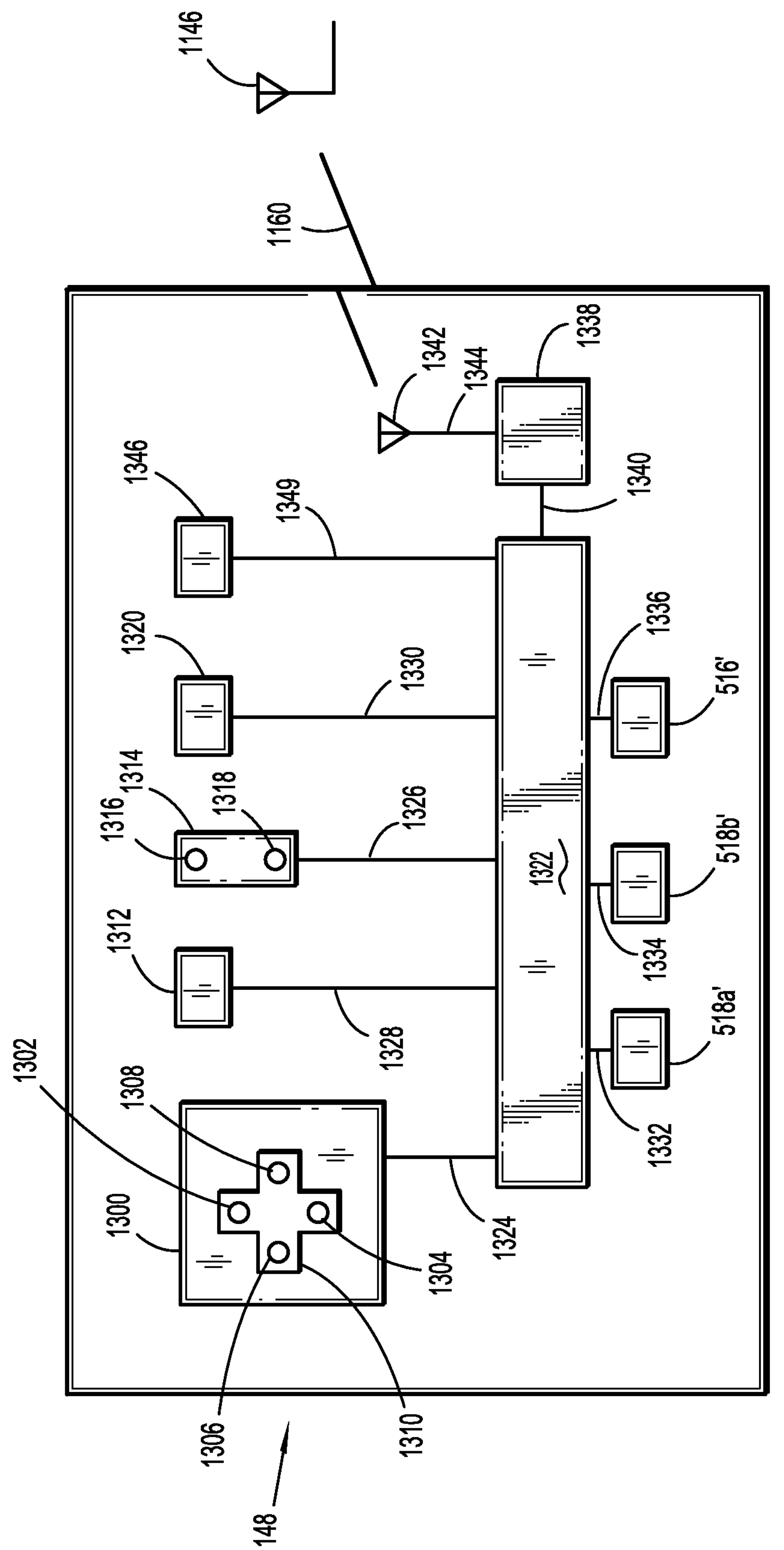
FIG. 28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1322
518b'
1334
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518a'
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1308
1332
1300
1324
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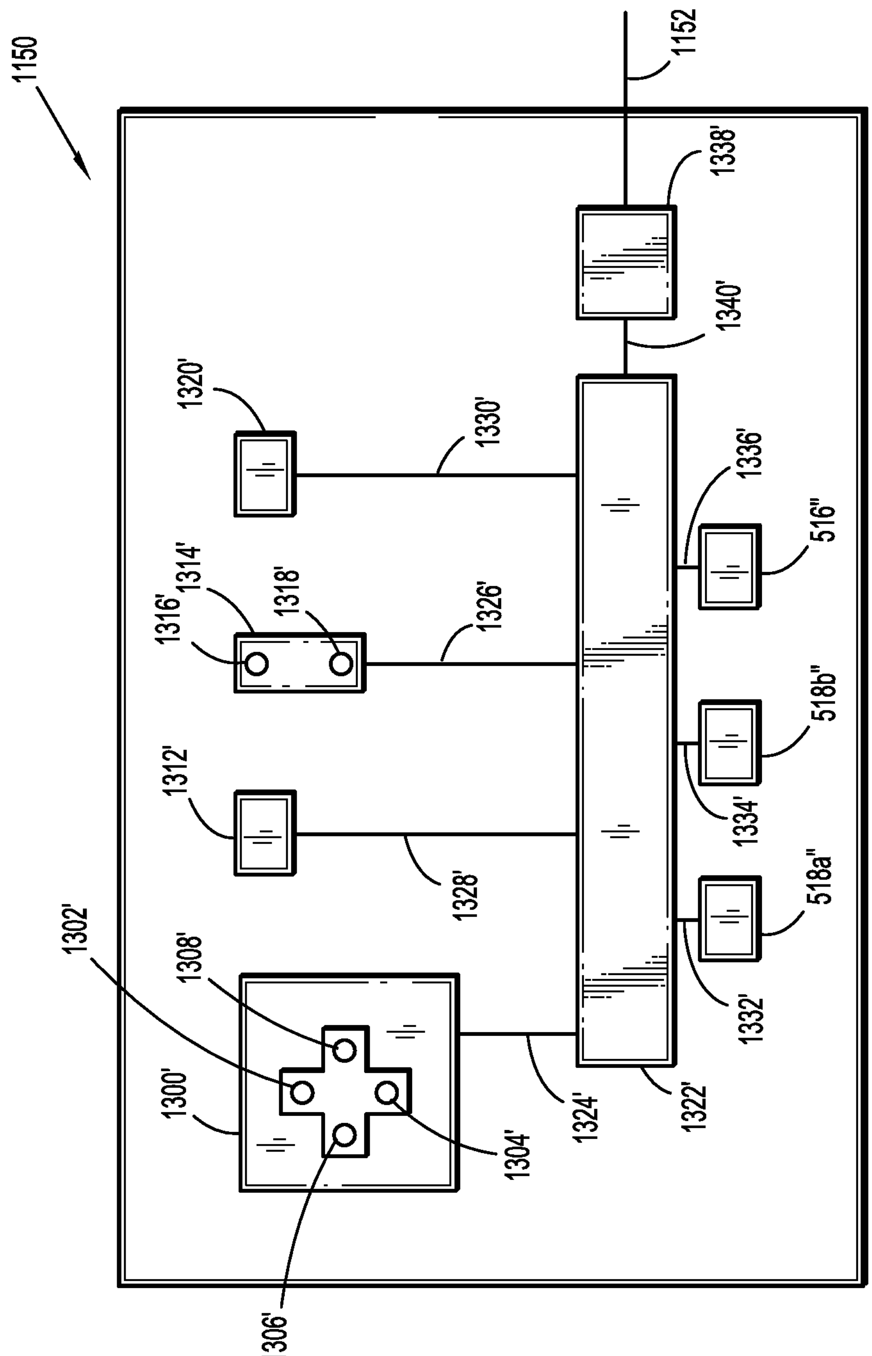
FIG. 29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516"
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1326'
518b"
1334'
1312'
1328'
518a"
1332'
1302'
1308'
1300'
1324'
1322'
1304'
1306'

FIG. 30

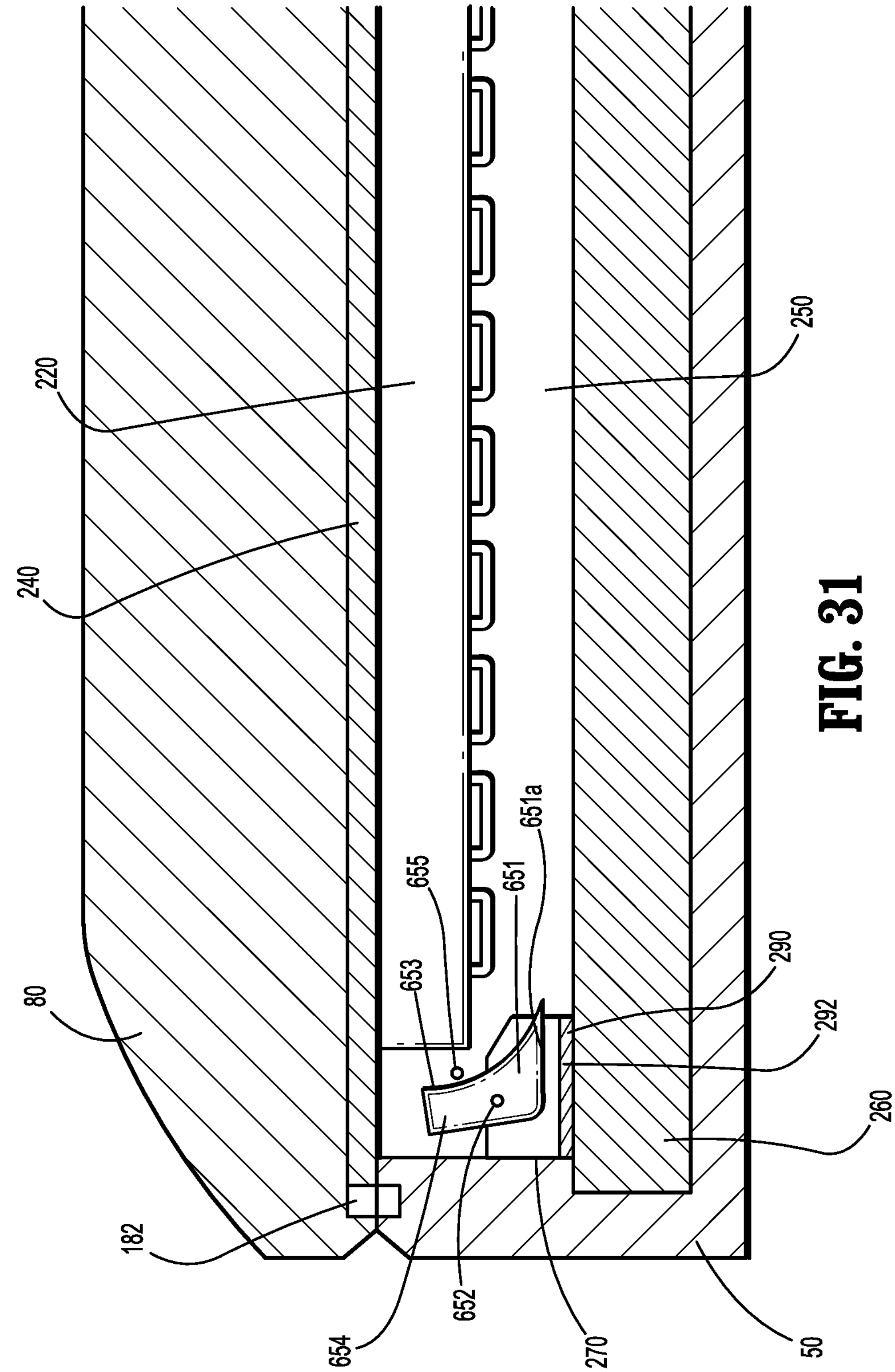

FIG. 31

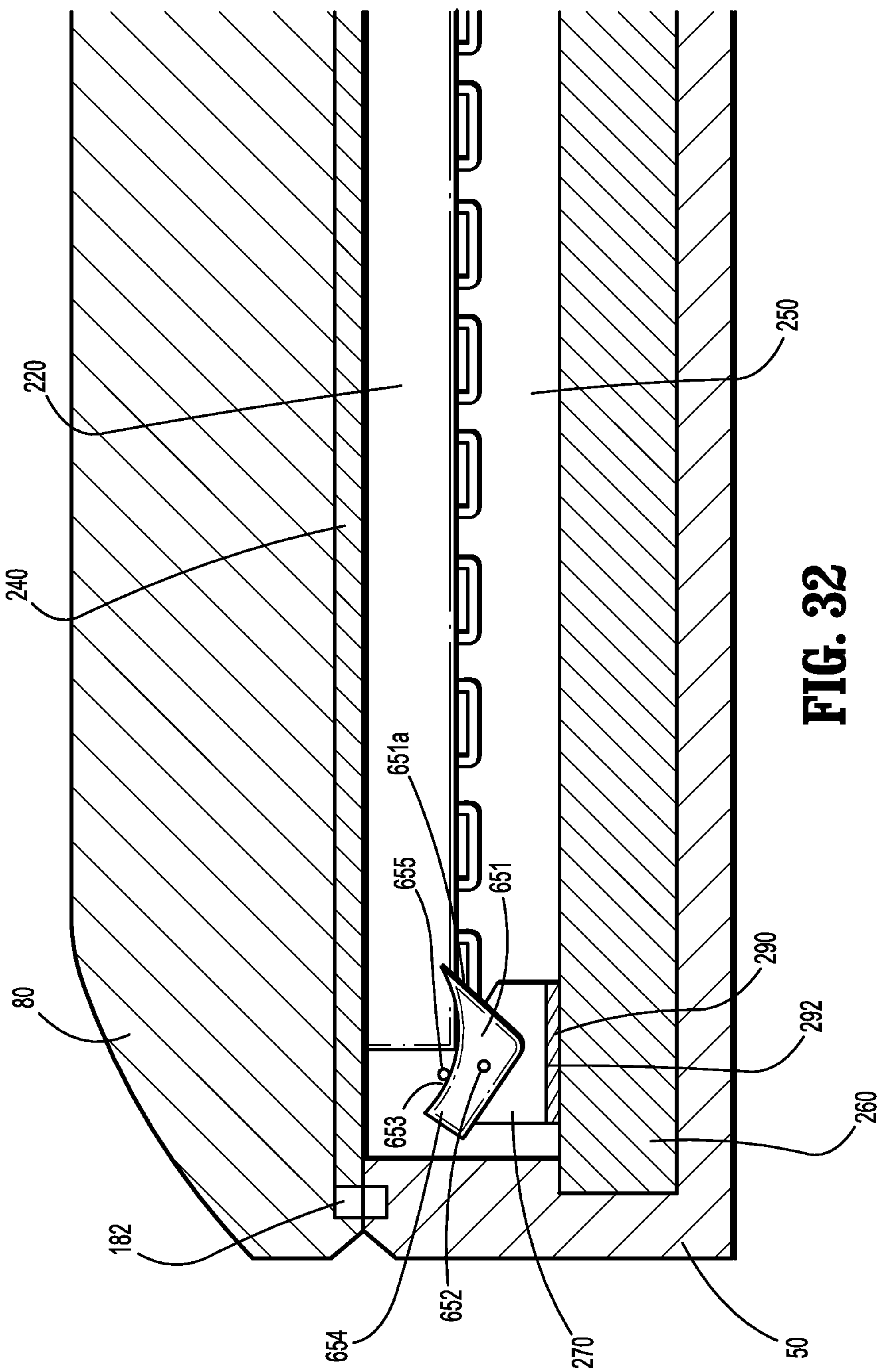

FIG. 32

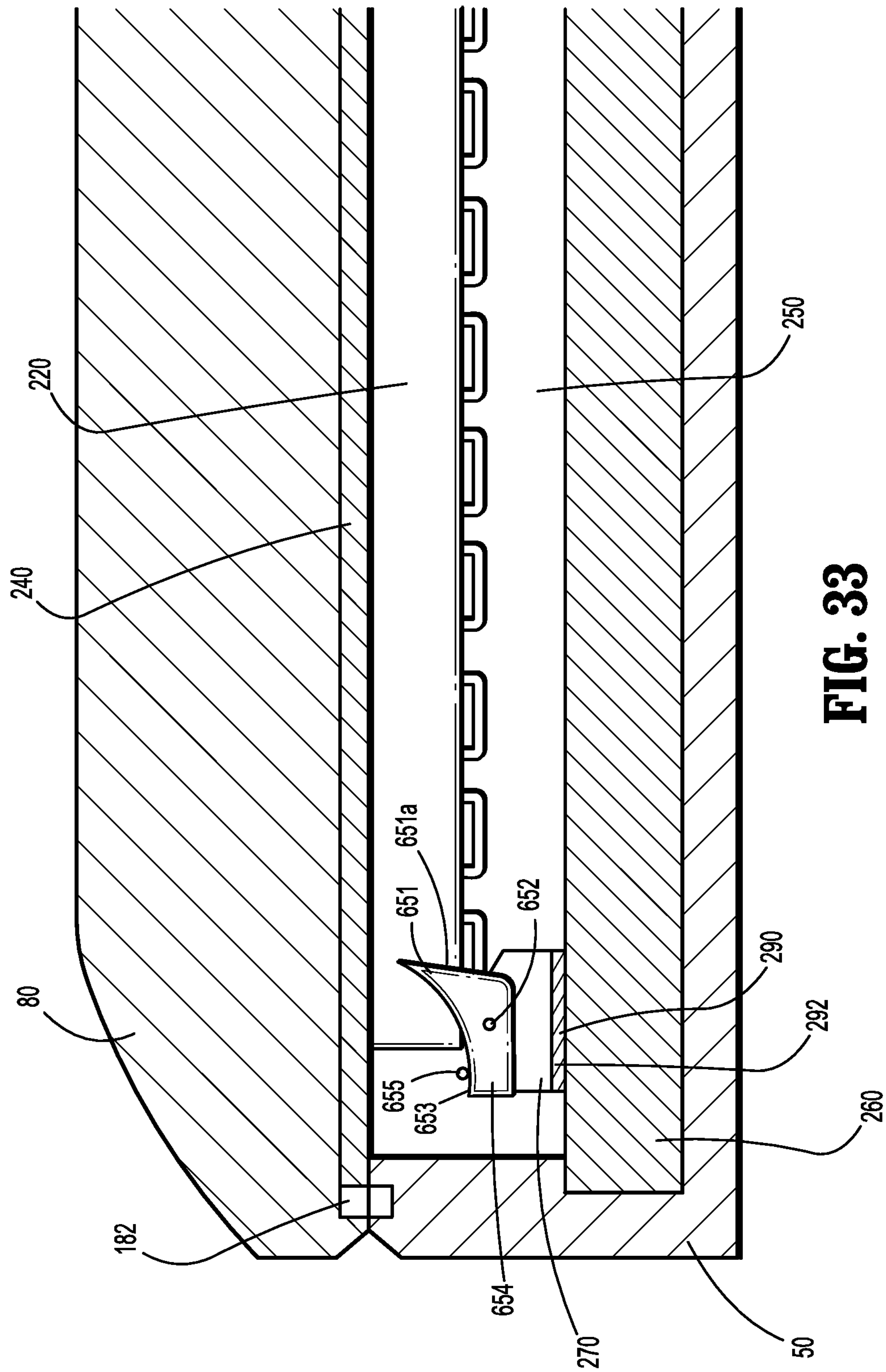

FIG. 33

SURGICAL DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a Continuation application claiming the benefit of and priority to U.S. application Ser. No. 13/964,228 (now U.S. Pat. No. 8,740,932), filed on Aug. 12, 2013, which is a Continuation application claiming the benefit of and priority to U.S. patent application Ser. No. 13/207,697 (now U.S. Pat. No. 8,512,359), filed Aug. 11, 2011, which is a Continuation application claiming the benefit of and priority to U.S. patent application Ser. No. 12/749,573 (now U.S. Pat. No. 8,021,373), filed Mar. 30, 2010, which is a Divisional application claiming the benefit of and priority to U.S. patent application Ser. No. 09/999,546 (now U.S. Pat. No. 7,695,485), filed on Nov. 30, 2001, the entire contents of which are incorporated herein by reference.

The present application incorporates herein each of the following references as fully as if set forth in their entirety: U.S. patent application Ser. No. 09/887,789, filed on Jun. 22, 2001 and issued as U.S. Pat. No. 7,032,798 on Apr. 25, 2006; U.S. patent application Ser. No. 09/836,781, filed on Apr. 17, 2001 and issued as U.S. Pat. No. 6,981,941 on Jan. 3, 2006; U.S. patent application Ser. No. 09/723,715, filed on Nov. 28, 2000 and issued as U.S. Pat. No. 6,793,652 on Sep. 21, 2004; U.S. patent application Ser. No. 09/324,451, filed on Jun. 2, 1999 and issued as U.S. Pat. No. 6,315,184 on Nov. 13, 2001; U.S. patent application Ser. No. 09/324,452, filed on Jun. 2, 1999 and issued as U.S. Pat. No. 6,443,973 on Sep. 3, 2002; U.S. patent application Ser. No. 09/351,534, filed on Jul. 12, 1999 and issued as U.S. Pat. No. 6,264,087 on Jul. 24, 2001; U.S. patent application Ser. No. 09/510,923, filed on Feb. 22, 2000 and issued as U.S. Pat. No. 6,517,565 on Feb. 11, 2003; and U.S. patent application Ser. No. 09/510,927, filed on Feb. 22, 2000 and issued as U.S. Pat. No. 6,716,233 on Apr. 6, 2004.

FIELD OF THE INVENTION

The present invention relates to a surgical device. More specifically, the present invention relates to a linear clamping, cutting and stapling device for clamping, cutting and stapling tissue.

BACKGROUND INFORMATION

The literature is replete with descriptions of surgical devices. Applicant's co-pending U.S. patent application Ser. No. 09/887,789 (now U.S. Pat. No. 7,032,798) lists some of these surgical devices, such as U.S. Pat. No. 4,705,038 to Sjostrom et al; U.S. Pat. No. 4,995,877 to Ams et al; U.S. Pat. No. 5,249,583 to Mallaby; U.S. Pat. No. 5,383,880 to Hooven; U.S. Pat. No. 5,395,033 to Byrne et al; U.S. Pat. No. 5,467,911 to Tsuruta et al; U.S. Pat. Nos. 5,518,163, 5,518,164 and 5,667,517, all to Hooven; U.S. Pat. No. 5,653,374 to Young et al.; U.S. Pat. No. 5,779,130 to Alesi et al.; and U.S. Pat. No. 5,954,259 to Viola et al.

One type of surgical device is a linear clamping, cutting and stapling device. An example of such a device is shown and described in U.S. Pat. No. 6,264,087 issued on Jul. 24, 2001. Such a device may be employed in a surgical procedure to resect a cancerous or anomalous tissue from a gastrointestinal tract.

With respect to the structural features of the conventional linear clamping, cutting and stapling instrument which is shown in FIG. 1, the device includes a pistol grip-styled structure having an elongated shaft and distal portion. The distal portion includes a pair of scissors-styled gripping elements, which clamp the open ends of the colon closed. In this device, one of the two scissors-styled gripping elements, the anvil portion, moves or pivots relative to overall structure, whereas the other gripping element remains fixed relative to the overall structure. The actuation of this scissoring device (the pivoting of the anvil portion) is controlled by a grip trigger maintained in the handle.

In addition to the scissoring device, the distal portion also includes a stapling mechanism. The fixed gripping element of the scissoring mechanism includes a staple cartridge receiving region and a mechanism for driving the staples up through the clamped end of the tissue, against the anvil portion, thereby sealing the previously opened end. The scissoring elements may be integrally formed with the shaft or may be detachable such that various scissoring and stapling elements may be interchangeable.

One problem with the foregoing surgical devices, and in particular with the foregoing linear clamping, cutting and stapling devices such as that illustrated in FIG. **1**, is the tendency of the opposing jaws of the clamping mechanism to be urged apart during the operation of cutting and stapling the tissue. Another problem with the foregoing surgical devices, and in particular with the foregoing linear clamping, cutting and stapling devices such as that illustrated in FIG. **1**, is that the devices are difficult to maneuver. Because a linear clamping, cutting and stapling device may be employed corporeally, e.g., inside the body of a patient, the device must be small enough to be maneuvered inside the body of a patient. Conventional linear clamping, cutting and stapling devices such as that illustrated in FIG. **1** have an overall length which increases the difficulty in maneuvering the device, especially inside the patient's body.

Still another problem with the foregoing surgical devices, and in particular with the foregoing linear clamping, cutting and stapling devices such as that illustrated in FIG. **1**, is that the torque required to cut and staple a section of tissue is undesirably high, thereby causing stress in various components of the devices. For instance, in other linear clamping, cutting and stapling devices which move scissoring and stapling elements from the proximal end to the distal end, a high torque is required to move the scissoring and stapling elements when the scissoring and stapling elements are at the distal end. Thus, when the cutting and stapling element has traveled to the distal end of the jaws, the high torque causes stress in the scissoring and stapling elements, and driver mechanisms of the device.

SUMMARY OF THE INVENTION

The present invention, according to one example embodiment thereof, relates to a surgical device, which includes a first jaw and a second jaw disposed in opposed correspondence with the first jaw. The second jaw is mechanically coupled to the first jaw at a proximal end opposite a distal end. A cutting element, having a blade facing the proximal end, is disposed within the second jaw, and a first driver is configured to move the cutting element from the distal end to the proximal end of the second jaw to thereby cut a section of tissue disposed between the first and second jaws.

According to an example embodiment, the device may include a stapling element disposed within the second jaw, wherein the cutting element and the stapling element are contiguous so as to define a single cutting and stapling element, such as a wedge having a blade disposed thereon. As the wedge is moved from the distal end of the second jaw to the proximal end, the wedge urges staples against opposing staple guides disposed in the first jaw in order to staple a section of tissue while the blade cuts the section of tissue.

By moving the cutting and stapling element from the distal end of the mechanism to the proximal end during the cutting and stapling operation, the example embodiment may reduce the tendency of the upper and lower jaws to separate during operation of the device. Specifically, by moving the cutting and stapling element from the distal end of the mechanism to the proximal end during the cutting and stapling operation, there may be a resulting reduction in the distance between the upper and lower jaws at their distal ends.

In addition, by moving the cutting and stapling element from the distal end of the mechanism to the proximal end during the cutting and stapling operation, the example embodiment may reduce the torque which is required during the cutting and stapling operation, thereby reducing the stress which is experienced by various components of the surgical device. By housing the cutting and stapling elements at the distal end of the mechanism, the example embodiment may also reduce the length of the surgical device relative to a conventional linear clamping, cutting and stapling device, thereby improving the device's maneuverability, especially when employed inside the body of a patient, and may enable the stroke (e.g., the distance which can be cut and stapled) to be lengthened so as to clamp, cut and staple a larger section of tissue than a conventional linear clamping, cutting and stapling device.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a conventional linear clamping, cutting and stapling device;

FIG. **2** is a perspective view of an electro-mechanical surgical system according to one example embodiment of the present invention;

FIGS. **3** and **4** are side views of the dosed and open dispositions, respectively, of a linear clamping, cutting and stapling attachment according to one example embodiment of the present invention;

FIGS. **5** and **6** are side sectional views of the closed and open dispositions, respectively, of the linear clamping, cutting and stapling attachment illustrated in FIGS. **3** to **4**;

FIG. **5**A is another sectional view of the closed disposition of the linear clamping, cutting and stapling attachment illustrated in FIGS. **3** to **6**;

FIGS. **7** to **14** are rear sectional views of the linear clamping, cutting and stapling attachment illustrated in FIGS. **3** to **6**;

FIGS. **15** to **19** are bottom, top sectional, deep top sectional, bottom sectional, and top views, respectively, of the linear clamping, cutting and stapling attachment illustrated in FIGS. **3** to **14**;

FIG. **20** is a side sectional of the linear clamping, cutting and stapling attachment illustrated in FIGS. **3** to **19**;

FIG. **21** is a side elevational view, partially in section, of a flexible shaft of the electro-mechanical surgical device according to one example embodiment of the present invention;

FIG. **22** is a cross-sectional view of the flexible shaft taken along the line **22-22** shown in FIG. **21**;

FIG. **23** is a rear end view of a first coupling of the flexible shaft illustrated in FIG. **21**;

FIG. **24** is a front end view of a second coupling of the flexible shaft illustrated in FIG. **21**;

FIG. **25** is a schematic view illustrating a motor arrangement of the electro-mechanical surgical device illustrated in FIG. **2**;

FIG. **26** is a schematic view of the electro-mechanical surgical device illustrated in FIG. **2**;

FIG. **27** is a schematic view of an encoder of the flexible shaft illustrated in FIG. **21**;

FIG. **28** is a schematic view of a memory device of a linear clamping, cutting and stapling device according to one example embodiment of the present invention;

FIG. **29** is a schematic view of a wireless remote control unit of the electro-mechanical surgical device illustrated in FIG. **2**;

FIG. **30** is a schematic view of a wired remote control unit of the electro-mechanical surgical device illustrated in FIG. **2**; and

FIGS. **31** to **33** are side sectional views of the closed disposition of the linear clamping, cutting and stapling attachment illustrating a cutting element which is moveably coupled to the stapling element according to one example embodiment of the present invention.

DETAILED DESCRIPTION

One example embodiment of a surgical device according to the present invention is illustrated in FIGS. **3** to **20**. Referring to FIGS. **3** and **4**, an example embodiment of the surgical device **11**, e.g., a linear clamping, cutting and stapling device, is illustrated. In this embodiment, a device **11** includes a parallel separating jaw system having a lower jaw **50** in opposite correspondence to an upper jaw **80** having a proximal end **100**. FIG. **3** illustrates the device **11** in a closed position, in which the lower jaw **50** and the upper jaw **80** are in contact at both their proximal and distal ends. FIG. **4** illustrates the device **11** in an open position, wherein the lower jaw **50** and the upper jaw **80** are separated. For the purposes of illustration only, FIGS. **3** to **20** illustrate the opposing jaws **50** and **80**, which remain parallel relative to each other. In an alternative example embodiment, opposing jaws **50** and **80** may open and close in scissor-like fashion, wherein the proximal ends of opposing jaws **50** and **80** are mechanically connected by a hinge or other rotational element such that the upper jaw **50** is rotatably coupled to the lower jaw **80**.

FIG. **5** is a side sectional view of the surgical device **11** in the closed position, corresponding to the view shown in FIG. **3**. FIG. **6**, on the other hand, is a side sectional view of the surgical device **11** in the open position, corresponding to the view shown in FIG. **4**. Referring now to either FIG. **5** or FIG. **6**, the proximal end **100** of the upper jaw **80** includes a pair of threaded vertical bores **90**, through which extend a corresponding pair of vertical shafts **130**. Inner threads **92** of the vertical bores **90** match outer threads **132** of the vertical shafts **130**. The vertical shafts **130** engage a threaded upper horizontal shaft **151** at a distal end **140** of the upper horizontal shaft **151**. The outer threads **152** of the upper horizontal shaft **151** interlock with the outer threads **132** of the vertical shafts **130**. The upper horizontal shaft **151** includes an upper drive socket **180** at a proximal end **170**.

FIG. **5**A is another sectional view of the closed disposition of the surgical device **11** illustrated in FIGS. **3** and **4**, according to an example embodiment of the present invention. FIG. **5**A illustrates the surgical device **11** coupled (removably or permanently) to an electro-mechanical surgical system **510**. The surgical device **11** includes a first driver **261** which is coupled to a first motor **576** of the system **510** by a first drive shaft **532**. As will be explained in more detail below, the first driver **261**, when engaged by the system **510**, operates to drive a cutting and stapling element within the lower jaw **50**. In addition, the surgical device **11** includes a second driver **150**, which is coupled to a second motor **580** of system **510** by a second drive shaft **530**. As will be explained in more detail below, second driver **150**, when engaged by system **510**, operates to open and close upper jaw **80** relative to lower jaw **50**.

Referring again to FIGS. **5** and **6**, the surgical device **11** further includes a cutting element and a stapling element, which includes a wedge **270**, having a blade **51** disposed thereon. In an alternative example embodiment, the cutting and stapling elements may be separately disposed. In the example embodiment, the blade **51** includes a cutting edge **51***a* that faces the proximal end **170** of the surgical device **11**. In the lower jaw **50** is disposed a tray **220**, which may be replaceable, housing one or more fasteners, e.g., staples **230**, and in the upper jaw **80** is disposed one or more staple guides **240** corresponding to the staples **230**. Each of the staples **230** includes a butt **232** protruding below the tray **220** and a pair of prongs **234** extending to the top of the tray **220**. The surgical device **11** further includes a wedge guide or channel **250** extending beneath the tray **220**. Within the channel **250** extends a threaded lower horizontal shaft **260** having outer threads **262**. Upon the lower horizontal shaft **260** travels the wedge **270** having a sloped top face **280**, a horizontal threaded bore **290** coaxial with the channel **250**, having inner threads **292** matching the outer threads **262** of the lower horizontal shaft **260**, and an upwardly extending blade member **51**. As previously mentioned, the blade member **51** includes a cutting edge **51***a* facing the proximal end **170** of the surgical device **11**. The lower horizontal shaft **260** has at a proximal end **300***a* second drive socket **310**.

In the example embodiment illustrated, the surgical device **11** also includes a first sensor electrode **182** electrically communicating via communication wires with a first contact pad **187** which electrically communicates with a second contact pad **189** via, e.g., direct contact. The second, contact pad **189** electrically communicates via the communication wires **188***a* with a first contact node **188**. Similarly, the surgical device **11** further includes a second sensor electrode **184** electrically communicating via communication wires with a second contact node **186** (illustrated in FIG. **7**). The contact nodes **186**, **188** electrically communicate with communication wires (not shown) in the electro-mechanical drive component **510** to form a sensor circuit, such that when the upper jaw **80** and the lower jaw **50** are clamped together, the sensor electrodes **182**, **184** are in contact, the sensor circuit is closed, and the operator is alerted via other circuit components (discussed in greater detail below) to the clamped position of the jaws **50**, **80**. The operator is therefore informed that it is safe and/or appropriate to begin a cutting and stapling process.

FIG. **7** is a rear sectional view, taken along the line **7-7**, of the surgical device **11** illustrated in FIG. **5**. FIG. **7** illustrates second contact node **186**, as well as upper drive socket **180** for engaging a first drive shaft and lower drive socket **310** for engaging a second drive shaft. FIG. **7** also illustrates data connector **1272** coupled to a data memory unit **1174** (illustrated in FIGS. **5** and **6**), the purpose and operation of which are discussed in greater detail below. FIG. **8** is a rear sectional view, taken along the line **8-8**, of the surgical device **11** illustrated in FIG. **5**. FIG. **9** is a rear sectional view, taken along the line **9-9**, of the surgical device **11** illustrated in FIG. **5**. FIG. **10** is a rear sectional view, taken along the line **10-10**, of the surgical device **11** illustrated in FIG. **5**.

FIG. **11** is a rear sectional view, taken along the line **11-11**, of the surgical device **11** illustrated in Figure. FIG. **12** is a rear sectional view, taken along the line **12-12**, of the surgical device **11** illustrated in FIG. **6**. FIG. **13** is a rear view, taken along the line **13-13**, of the surgical device **11** illustrated in FIG. **6**. FIG. **14** is a rear view, taken along the line **14-14**, of the surgical device **11** illustrated in FIG. **6**.

FIG. **15** is a bottom view, taken along the line **15-15**, of the surgical device **11** illustrated in FIGS. **5** and **6**. FIG. **16** is a top sectional view, taken along the line **16-16**, of the surgical device **11** illustrated in FIGS. **5** and **6**. FIG. **17** is a deep top sectional view, taken along the line **17-17**, of the surgical device **11** illustrated in FIGS. **5** and **6**. FIG. **18** is a bottom sectional view, taken along the line **18-18**, of the surgical device **11** illustrated in FIGS. **5** and **6**. FIG. **19** is a top view, taken along the line **19-19**, of the surgical device **11** illustrated in FIGS. **5** and **6**. FIG. **20** is a side sectional view, taken along the line **20-20**, of the surgical device **11** illustrated in FIGS. **5** and **6**.

Each of the example embodiments described above include a wedge **270** having a blade **51** fixedly disposed thereon. According to another example embodiment of the present invention, the surgical device **11** includes a blade which is moveably coupled or mounted to a wedge so that the blade may move between a first position and a second position relative to the wedge. According to one embodiment, a first position of the blade relative to the wedge may be in a retracted position, whereas a second position of the blade relative to the wedge may be in an operable position, e.g., wherein the cutting edge of the blade faces the proximal end of the lower jaw **50** of the surgical device **11**.

FIGS. **31** through **33** illustrate an example embodiment, wherein the surgical device **11** includes a blade **651** rotatably coupled to a wedge **670** so as to rotate between a first and a second position. The operation of the surgical device **11** shown in FIGS. **31** through **33** is discussed in greater detail below. FIGS. **31** through **33** illustrate the wedge **270** located at the distal end of the lower jaw **50**. The blade **651** is rotatably mounted to the wedge **270** by a pivot member **652**. The blade **651** includes a cutting edge **651***a* that is initially disposed in a retracted or down position, e.g., facing lower horizontal shaft **260**. The blade **651** also includes a tail region **654** having an actuating pin receiving face **653** which initially faces the proximal end **170** of the surgical device **11**. Located adjacent to actuating pin receiving face **653** is fixed actuating pin **655**, which according to the example embodiment illustrated, is fixedly attached to lower jaw **50**.

According to one example embodiment of the present invention, the surgical device **11** may be configured as an attachment to, or may be integral with, an electro-mechanical surgical system, such as electro-mechanical surgical system **510**. In another embodiment, the surgical device may be configured as an attachment to, or may integral with, a purely mechanical device driver system, such as that illustrated in FIG. **1**.

FIG. **2** is a perspective view of an example embodiment of an electro-mechanical surgical system **510** according to the present invention. Electro-mechanical surgical system **510** may include, for example, a remote power console **512**, which includes a housing **514** having a front panel **515**. Mounted on front panel **515** are a display device **516** and indicators **518***a*, **518***b*, which are more fully described hereinbelow. A flexible shaft **520** may extend from housing **514** and may be detachably secured thereto via a first coupling **522**. The distal end **524** of flexible shaft **520** may include a second coupling **526** adapted to detachably secure, e.g., the surgical device **11** described above, to the distal end **524** of flexible shaft **520**. It is noted, however, that the second coupling **526** may also be adapted to detachably secure a different surgical instrument or attachment. In another embodiment, the distal end **524** of the flexible shaft **520** may permanently secure or be integral with a surgical instrument.

Referring to FIG. **21**, there is seen a side view, partially in section, of flexible shaft **520**. According to one embodiment, flexible shaft **520** includes a tubular sheath **528**, which may include a coating or other sealing arrangement to provide a fluid-tight seal between the interior channel **540** thereof and the environment. Sheath **528** may be formed of a tissue-compatible, sterilizable elastomeric material. The sheath **528** may also be formed of a material that is autoclavable. Disposed within the interior channel **540** of flexible shaft **520**, and extending along the entire length thereof, may be a second rotatable drive shaft **530**, a first rotatable drive shaft **532**, a first steering cable **534**, a second steering cable **535**, a third steering cable **536**, a fourth steering cable **537** and a data transfer cable **538**. FIG. **22** is a cross-sectional view of flexible shaft **520** taken along the line **22-22** shown in FIG. **21** and further illustrates the several cables **530**, **532**, **534**, **535**, **536**, **537**, **538**. Each distal end of the steering cables **534**, **535**, **536**, **537** is affixed to the distal end **524** of the flexible shaft **520**. Each of the several cables **530**, **532**, **534**, **535**, **536**, **537**, **538** may be contained within a respective sheath.

The second rotatable drive shaft **530** and the first rotatable drive shaft **532** may be configured, for example, as highly flexible drive shafts, such as, for example, braided or helical drive cables. It should be understood that such highly flexible drive cables have limited torque transmission characteristics and capabilities. It should also be understood that the surgical device **11** (or other attachments connected to the flexible shaft **520**) may require a higher torque input than the torque transmittable by the drive shafts **530**, **532**. The drive shafts **530**, **532** may thus be configured to transmit low torque but high speed, the high speed/low torque being converted to low speed/high torque by gearing arrangements disposed, for example, at the distal end and/or the proximal end of the drive flexible shaft **520**, in the surgical instrument or attachment and/or in the remote power console **512**. It should be appreciated that such gearing arrangement(s) may be provided at any suitable location along the power train between the motors disposed in the housing **514** and the attached surgical instrument or other attachment connected to the flexible shaft **520**. Such gearing arrangement(s) may include, for example, a spur gear arrangement, a planetary gear arrangement, a harmonic gear arrangement, cycloidal drive arrangement, an epicyclic gear arrangement, etc.

Referring now to FIG. **23**, there is seen a rear end view of first coupling **522**. First coupling **522** includes a first connector **544**, a second connector **548**, a third connector **552** and a fourth connector **556**, each rotatably secured to first coupling **522**. Each of the connectors **544**, **548**, **552**, **556** includes a respective recess **546**, **550**, **554**, **558**. As shown in FIG. **23**, each recess **546**, **550**, **554**, **558** may be hexagonally shaped. It should be appreciated, however, that the recesses **546**, **550**, **554**, **558** may have any shape and configuration to non-rotatably couple and rigidly attach the connectors **544**, **548**, **552**, **556** to respective drive shafts of the motor arrangement contained within the housing **512**, as more fully described below. It should be appreciated that complementary projections may be provided on respective drive shafts of the motor arrangement to thereby drive the drive elements of the flexible shaft **520** as described below. It should also be appreciated that the recesses may be provided on the drive shafts and complementary projections may be provided on the connectors **544**, **548**, **552**, **556**. Any other coupling arrangement configured to non-rotatably and releasably couple the connectors **544**, **548**, **552**, **556** and the drive shafts of the motor arrangement may be provided.

One of the connectors **544**, **548**, **552**, **556** is non-rotatably secured to the second drive shaft **530**, and another one of the connectors **544**, **548**, **552**, **556** is non-rotatably secured to the first drive shaft **532**. The remaining two of the connectors **544**, **548**, **552**, **556** engage with transmission elements configured to apply tensile forces on the steering cables **534**, **535**, **536**, **537** to thereby steer the distal end **524** of the flexible shaft **520**. The data transfer cable **538** is electrically and logically connected with data connector **560**. Data connector **560** includes, for example, electrical contacts **562**, corresponding to and equal in number to the number of individual wires contained in the data cable **538**. First coupling **522** includes a key structure **542** to properly orient the first coupling **522** to a mating and complementary coupling arrangement disposed on the housing **512**. Such key structure **542** may be provided on either one, or both, of the first coupling **522** and the mating and complementary coupling arrangement disposed on the housing **512**. First coupling **522** may include a quick-connect type connector, which may use, for example, a simple pushing motion to engage the first coupling **522** to the housing **512**. Seals may be provided in conjunction with any of the several connectors **544**, **548**, **552**, **556**, **560** to provide a fluid-tight seal between the interior of first coupling **522** and the environment.

Referring now to FIG. **24**, there is seen a front end view of the second coupling **526** of flexible shaft **520**. In the example embodiment, the second coupling **526** includes a first connector **566** and a second connector **568**, each being rotatably secured to the second coupling **526** and each being non-rotatably secured to a distal end of a respective one of the first and second drive shafts **532**, **530**. A quick-connect type fitting **564** is provided on the second coupling **526** for detachably securing the device **11** thereto. The quick-connect type fitting **564** may be, for example, a rotary quick-connect type fitting, a bayonet type fitting, etc. A key structure **574** is provided on the second coupling **526** for properly aligning the device **11** to the second coupling **526**. The key structure or other arrangement for properly aligning the device **11** to the flexible shaft **520** may be provided on either one, or both, of the second coupling **526** and the device **11**. In addition, the quick-connect type fitting may be provided on the device **11**. A data connector **570**, having electrical contacts **572**, is also provided in the second coupling **526**. Like the data connector **560** of first coupling **522**, the data connector **570** of second coupling **526** includes contacts **572** electrically and logically connected to the respective wires of data transfer cable **538** and contacts **562** of data connector **560**. Seals may be provided in conjunction with the connectors **566**, **568**, **570** to provide a fluid-tight seal between the interior of second coupling **526** and the environment.

Disposed within housing **514** of the remote power console **512** are electro-mechanical driver elements configured to drive the drive shafts **530**, **532** and the steering cables **534**, **535**, **536**, **537** to thereby operate the electro-mechanical surgical system **510** and the linear clamping, cutting and stapling device **11** attached to the second coupling **526**. In the example embodiment illustrated schematically in FIG. **25**, five electric motors **576**, **580**, **584**, **590**, **596**, each operating via a power source, may be disposed in the remote power console **512**. It should be appreciated, however, that any appropriate number of motors may be provided, and the motors may operate via battery power, line current, a DC power supply, an electronically controlled DC power supply, etc. It should also be appreciated that the motors may be connected to a DC power supply, which is in turn connected to line current and which supplies the operating current to the motors.

FIG. **25** illustrates schematically one possible arrangement of motors. An output shaft **578** of a first motor **576** engages with the first connector **544** of the first coupling **522** when the first coupling **522**, and, therefore, flexible shaft **520**, is engaged with the housing **514** to thereby drive the second drive shaft **530** and first connector **566** of second coupling **526**. Similarly, an output shaft **582** of a second motor **580** engages the second connector **548** of first coupling **522** when first coupling **522**, and, therefore, flexible shaft **520** is engaged with the housing **514** to thereby drive the first drive shaft **532** and second connector **568** of second coupling **526**. An output shaft **586** of a third motor **584** engages the third connector **552** of the first coupling **522** when the first coupling **522**, and, therefore, flexible shaft **520**, is engaged with the housing **514** to thereby drive the first and second steering cables **534**, **535** via a first pulley arrangement **588**. An output shaft **592** of a fourth motor **590** engages the fourth connector **556** of the first coupling **522** when the first coupling **522**, and, therefore, flexible shaft **520**, is engaged with the housing **514** to thereby drive the third and fourth steering cables **536**, **537** via a second pulley arrangement **594**. The third and fourth motors **584**, **590** may be secured on a carriage **1100**, which is selectively movable via an output shaft **598** of a fifth motor **596** between a first position and a second position to selectively engage and disengage the third and fourth motors **584**, **590** with the respective pulley arrangement **588**, **594** to thereby permit the flexible shaft **520** to become taut and steerable or limp as necessary. It should be appreciated that other mechanical, electrical or electro-mechanical mechanisms may be used to selectively engage and disengage the steering mechanism. The motors may be arranged and configured as described, for example, in U.S. patent application Ser. No. 09/510,923 (now U.S. Pat. No. 6,517,565), entitled "A Carriage Assembly for Controlling a Steering Wire Mechanism Within a Flexible Shaft," which is hereby incorporated by reference herein as fully as if set forth in its entirety.

It should be appreciated, that any one or more of the motors **576**, **580**, **584**, **590**, **596** may be high-speed/low-torque motors or low-speed/high-torque motors. As indicated above, the second rotatable drive shaft **530** and the first rotatable drive shaft **532** may be configured to transmit high speed and low torque. Thus, the first motor **576** and the second motor **580** may be configured as high-speed/low-torque motors.

Alternatively, the first motor **576** and the second motor **580** may be configured as low-speed/high-torque motors with a torque-reducing/speed-increasing gear arrangement disposed between the first motor **576** and the second motor **580** and a respective one of the second rotatable drive shaft **530** and the first rotatable drive shaft **532**. Such torque-reducing/speed-increasing gear arrangement may include, for example, a spur gear arrangement, a planetary gear arrangement, a harmonic gear arrangement, cycloidal drive arrangement, an epicyclic gear arrangement, etc. It should be appreciated that any such gear arrangement may be disposed within the remote power console **512** or in the proximal end of the flexible shaft **520**, such as, for example, in the first coupling **522**. It should be appreciated that the gear arrangement(s) are provided at the distal and/or proximal ends of the second rotatable drive shaft **530** and/or the first rotatable drive shaft **532** to prevent windup and breakage thereof.

Referring now to FIG. **26**, there is seen a schematic view of the example electro-mechanical surgical system **510**. A controller **1122** is provided in the housing **514** of remote power console **512** and is configured to control all functions and operations of the electro-mechanical surgical system **510** and the linear clamping, cutting and stapling device **11** attached to the flexible shaft **520**. A memory unit **1130** is provided and may include memory devices, such as, a ROM component **1132** and/or a RAM component **1134**. ROM component **1132** is in electrical and logical communication with controller **1122** via line **1136**, and RAM component **1134** is in electrical and logical communication with controller **1122** via line **1138**. RAM component **1134** may include any type of random-access memory, such as, for example, a magnetic memory device, an optical memory device, a magneto-optical memory device, an electronic memory device, etc.

Similarly, ROM component **1132** may include any type of read-only memory, such as, for example, a removable memory device, such as a PC-Card or PCMCIA-type device. It should be appreciated that ROM component **1132** and RAM component **1134** may be embodied as a single unit or may be separate units and that ROM component **1132** and/or RAM component **1134** may be provided in the form of a PC-Card or PCMCIA-type device.

Controller **1122** is further connected to front panel **515** of housing **514** and, more particularly, to display device **516** via line **1154** and indicators **518*a***, **518*b*** via respective lines **1156**, **1158**. Lines **1116**, **1118**, **1124**, **1126**, **1128** electrically and logically connect controller **1122** to first, second, third, fourth and fifth motors **576**, **580**, **584**, **590**, **596**, respectively. A wired remote control unit ("RCU") **1150** is electrically and logically connected to controller **1122** via line **1152**. A wireless RCU **1148** is also provided and communicates via a wireless link **1160** with a receiving/sending unit **1146** connected via line **1144** to a transceiver **1140**. The transceiver **1140** is electrically and logically connected to controller **1122** via line **1142**. Wireless link **1160** may be, for example, an optical link, such as an infrared link, a radio link or any other form of wireless communication link.

A switch device **1186**, which may be, for example, an array of DIP switches, may be connected to controller **1122** via line **1188**. Switch device **1186** may be used, for example, to select one of a plurality of languages used in displaying messages and prompts on the display device **516**. The messages and prompts may relate to, for example, the operation and/or the status of the electro-mechanical surgical system **510** and/or to the surgical device **11** attached thereto.

According to the example embodiment of the present invention, a first encoder **1106** is provided within the second coupling **526** and is configured to output a signal in response to and in accordance with the rotation of the second drive shaft **530**. A second encoder **1108** is also provided within the second coupling **526** and is configured to output a signal in response to and in accordance with the rotation of the first drive shaft **532**. The signal output by each of the encoders **1106**, **1108** may represent the rotational position of the respective drive shaft **530**, **532** as well as the rotational direction thereof. Such encoders **1106**, **1108** may be, for example, Hall-effect devices, optical devices, etc. Although the encoders **1106**, **1108** are described as being disposed within the second coupling **526**, it should be appreciated that the encoders **1106**, **1108** may be provided at any location between the motor system and the linear clamping, cutting and stapling device. It should be appreciated that providing the encoders **1106**, **1108** within the second coupling **526** or at the distal end of the flexible shaft **520** provides for an accurate determination of the drive shaft rotation. If the encoders **1106**, **1108** are disposed at the proximal end of the flexible shaft **520**, windup of the first and second rotatable drive shafts **532**, **530** may result in measurement error.

FIG. **27** is a schematic view of an encoder **1106**, **1108**, which includes a Hall-effect device. Mounted non-rotatably on drive shaft **530**, **532** is a magnet **1240** having a north pole **1242** and a south pole **1244**. The encoder **1106**, **1108** further includes a first sensor **1246** and second sensor **1248**, which are disposed approximately 90° apart relative to the longitudinal, or rotational, axis of drive shaft **530**, **532**. The output of the sensors **1246**, **1248** is persistent and changes its state as a function of a change of polarity of the magnetic field in the detection range of the sensor. Thus, based on the output signal from the encoders **1106**, **1108**, the angular position of the drive shaft **530**, **532** may be determined within one-quarter revolution and the direction of rotation of the drive shaft **530**, **532** may be determined. The output of each encoder **1106**, **1108** is transmitted via a respective line **1110**, **1112** of data transfer cable **538** to controller **1122**. The controller **1122**, by tracking the angular position and rotational direction of the drive shafts **530**, **532** based on the output signal from the encoders **1106**, **1108**, can thereby determine the position and/or state of the components of the linear clamping, cutting and stapling device connected to the electro-mechanical surgical system **510**.

That is, by counting the revolutions of the drive shaft **530**, **532**, the controller **1122** can determine the position and/or state of the components of the linear clamping, cutting and stapling device connected to the electro-mechanical surgical system **510**.

For instance, the advancement distance of upper jaw **80** relative to lower jaw **50**, and of the wedge **270** are functions of, and ascertainable on the basis of, the rotation of the respective drive shaft **530**, **532**. By ascertaining an absolute position of the jaw **80** and the wedge **270** at a point in time, the relative displacement of the jaw **80** and wedge **270**, based on the output signal from the encoders **1106**, **1108** and the known pitches of the vertical drive shaft **1132** and lower horizontal shaft **260**, may be used to ascertain the absolute position of the jaw **80** and the wedge **270** at all times thereafter. The absolute position of the jaw **80** and the wedge **270** may be fixed and ascertained at the time that the surgical device **11** is first coupled to the flexible shaft **520**. Alternatively, the position of the jaw **80** and the wedge **270** relative to, for example, the lower jaw **50** may be determined based on the output signal from the encoders **1106**, **1108**.

The surgical device **11** may further include, according to one embodiment and as illustrated in FIG. **5**, a data connector **1272** adapted by size and configuration to electrically and logically connect to connector **570** of second coupling **526**. In the example embodiment, data connector **1272** includes contacts equal in number to the number of leads **572** of connector **570**. Contained within the surgical device **11** is a memory unit **1174** electrically and logically connected with the data connector **1272**. Memory unit **1174** may be in the form of, for example, an EEPROM, EPROM, etc. and may be contained, for example, within the lower jaw **50** of the surgical device **11**.

FIG. **28** schematically illustrates the memory unit **1174**. As seen in FIG. **28**, data connector **1272** includes contacts **1276**, each electrically and logically connected to memory unit **1174** via a respective line **1278**. Memory unit **1174** is configured to store, for example, a serial number data **1180**, an attachment type identifier (ID) data **1182** and a usage data **1184**. Memory unit **1174** may additionally store other data. Both the serial number data **1180** and the ID data **1182** may be configured as read-only data. In the example embodiment, serial number data **1180** is data uniquely identifying the particular linear clamping, cutting and stapling device, whereas the ID data **1182** is data identifying the type of the attachment (when, for instance, other types of attachments may be employed by the device). The usage data **1184** represents usage of the particular attachment, such as, for example, the number of times the upper jaw **80** of the surgical device **11** has been opened and closed, or the number of times that the wedge **270** of the surgical device **11** has been advanced or fired.

It should be appreciated that the attachment attachable to the distal end **524** of the flexible shaft **520**, e.g., surgical device **11**, may be designed and configured to be used a single time or multiple times. The attachment may also be designed and configured to be used a predetermined number of times. Accordingly, the usage data **1184** may be used to determine whether the surgical device **11** has been used and whether the number of uses has exceeded the maximum number of permitted uses. As more fully described below, an attempt to use the attachment after the maximum number of permitted uses has been reached will generate an ERROR condition.

Referring again to FIG. **26**, in accordance with the example embodiment of the present invention, the controller **1122** is configured to read the ID data **1182** from the memory unit **1174** of surgical device **11** when the surgical device **11** is initially connected to the flexible shaft **520**. The memory unit **1174** is electrically and logically connected to the controller **1122** via line **1120** of data transfer cable **538**. Based on the read ID data **1182**, the controller **1122** is configured to read or select from the memory unit **1130**, an operating program or algorithm corresponding to the type of surgical instrument or attachment connected to the flexible shaft **520**. The memory unit **1130** is configured to store the operating programs or algorithms for each available type of surgical instrument or attachment, the controller **1122** selecting and/or reading the operating program or algorithm from the memory unit **1130** in accordance with the ID data **1182** read from the memory unit **1174** of an attached surgical instrument or attachment. As indicated above, the memory unit **1130** may include a removable ROM component **1132** and/or RAM component **1134**. Thus, the operating programs or algorithms stored in the memory unit **1130** may be updated, added, deleted, improved or otherwise revised as necessary. The operating programs or algorithms stored in the memory unit **1130** may be customizable based on, for example, specialized needs of the user. A data entry device, such as, for example, a keyboard, a mouse, a pointing device, a touch screen, etc., may be connected to the memory unit **1130** via, for example, a data connector port, to facilitate the customization of the operating programs or algorithms. Alternatively or additionally, the operating programs or algorithms may be customized and preprogramed into the memory unit **1130** remotely from the electro-mechanical surgical system **510**. It should be appreciated that the serial number data **1180** and/or usage data **1184** may also be used to determine which of a plurality of operating programs or algorithms is read or selected from the memory unit **1130**. It should be appreciated that the operating program or algorithm may alternatively be stored in the memory unit **1174** of the surgical device **11** and transferred to the controller **1122** via the data transfer cable **538**. Once the appropriate operating program or algorithm is read or selected by, or transmitted to, the controller **1122**, the controller **1122** causes the operating program or algorithm to be executed in accordance with operations performed by the user via the wired RCU **1150** (described below) and/or the wireless RCU **1148** (described below). As indicated hereinabove, the controller **1122** is electrically and logically connected with the first, second, third, fourth and fifth motors **576**, **580**, **584**, **590**, **596** via respective lines **1116**, **1118**, **1124**, **1126**, **1128** and controls such motors **576**, **580**, **584**, **590**, **596** in accordance with the read, selected or transmitted operating program or algorithm via the respective lines **1116**, **1118**, **1124**, **1126**, **1128**.

Referring now to FIG. **29**, there is seen a schematic view of wireless RCU **1148**. Wireless RCU **1148** includes a steering controller **1300** having a plurality of switches **1302**, **1304**, **1306**, **1308** arranged under a four-way rocker **1310**. The operation of switches **1302**, **1304**, via rocker **1310**, controls the operation of first and second steering cables **534**, **535** via third motor **584**. Similarly, the operation of switches **1306**, **1308**, via rocker **1310**, controls the operation of third and fourth steering cables **536**, **537** via fourth motor **592**. It should be appreciated that rocker **1310** and switches **1302**, **1304**, **1306**, **1308** are arranged so that the operation of switches **1302**, **1304** steers the flexible shaft **520** in the north-south direction and that the operation of switches **1306**, **1308** steers the flexible shaft **520** in the east-west direction. Reference herein to north, south, east and west is made to a relative coordinate system. Alternatively, a digital joystick, analog joystick, etc. may be provided in place of rocker **1310** and switches **1302**, **1304**, **1306**,**1308**. Potentiometers or any other type of actuator may also be used in place of switches **1302**, **1304**, **1306**, **1308**.

Wireless RCU **1148** further includes a steering engage/disengage switch **1312**, the operation of which controls the operation of fifth motor **596** to selectively engage and disengage the steering mechanism. Wireless RCU **1148** also includes a two-way rocker **1314** having first and second switches **1316**, **1318** operable thereby. The operation of these switches **1316**, **1318** controls certain functions of the electro-mechanical surgical system **510** and any surgical instrument or attachment, such as the surgical device **11**, attached to the flexible shaft **520** in accordance with the operating program or algorithm corresponding to the attached device **11**. For example, operation of the two-way rocker **1314** may control the opening and closing of the upper and lower jaws of the surgical device **11**. Wireless RCU **1148** is provided with yet another switch **1320**, the operation of which may further control the operation of the electro-mechanical surgical system **510** and the device attached to the flexible shaft **520** in accordance with the operating program or algorithm corresponding to the attached device. For example, operation of the switch **1320** may initiate the advancement, or firing sequence, of the wedge **270** of the surgical device **11**. Wireless RCU **1148** includes a controller **1322**, which is electrically and logically connected with the switches **1302**, **1304**, **1306**, **1308** via line **1324**, with the switches **1316**, **1318** via line **1326**, with switch **1312** via line **1328** and with switch **1320** via line **1330**. Wireless RCU **1148** may include indicators **518*a*'**, **518*b*'**, corresponding to the indicators **518*a***, **518*b*** of front panel **515**, and a display device **516'**, corresponding to the display device **516** of the front panel **515**. If provided, the indicators **518*a*'**, **518*b*'** are electrically and logically connected to controller **1322** via respective lines **1332**, **1334**, and the display device **516'** is electrically and logically connected to controller **1322** via line **1336**. Controller **1322** is electrically and logically connected to a transceiver **1338** via line **1340**, and transceiver **1338** is electrically and logically connected to a receiver/transmitter **1342** via line **1344**. A power supply, not shown, for example, a battery, may be provided in wireless RCU **1148** to power the same. Thus, the wireless RCU **1148** may be used to control the operation of the electro-mechanical surgical system **510** and the device **11** attached to the flexible shaft **520** via wireless link **1160**.

Wireless RCU **1148** may include a switch **1346** connected to controller **1322** via line **1348**. Operation of switch **1346** transmits a data signal to the transmitter/receiver **1146** via wireless link **1160**. The data signal includes identification data uniquely identifying the wireless RCU **1148**. This identification data is used by the controller **1122** to prevent unauthorized operation of the electro-mechanical surgical system **510** and to prevent interference with the operation of the electro-mechanical surgical system **510** by another wireless RCU. Each subsequent communication between the wireless RCU **1148** and the electro-mechanical device surgical **510** may include the identification data. Thus, the controller **1122** can discriminate between wireless RCUs and thereby allow only a single, identifiable wireless RCU **1148** to control the operation of the electro-mechanical surgical system **510** and the device **11** attached to the flexible shaft **520**.

Based on the positions of the components of the device attached to the flexible shaft **520**, as determined in accordance with the output signals from the encoders **1106**, **1108**, the controller **1122** may selectively enable or disable the functions of the electro-mechanical surgical system **510** as defined by the operating program or algorithm corresponding to the attached device. For example, for the surgical device **11**, the firing function controlled by the operation of the switch **1320** is disabled unless the space or gap between lower jaw **50** and upper jaw **80** is determined to be within an acceptable range. The space or gap between lower jaw **50** and upper jaw **80** is determined based on the output signal from the encoders **1106**, **1108**, as more fully described hereinabove. It should be appreciated that, in the example embodiment, the switch **1320** itself remains operable but the controller **1122** does not effect the corresponding function unless the space or gap is determined to be within the acceptable range.

Referring now to FIG. **30**, there is seen a schematic view of a wired RCU **1150**. In the example embodiment, wired RCU **1150** includes substantially the same control elements as the wireless RCU **1148** and further description of such elements is omitted. Like elements are noted in FIG. **30** with an accompanying prime. It should be appreciated that the functions of the electro-mechanical surgical system **510** and the device attached to the flexible shaft **520** (e.g., the surgical device **11**) may be controlled by the wired RCU **1150** and/or by the wireless RCU **1148**. In the event of a battery failure, for example, in the wireless RCU **1148**, the wired RCU **1150** may be used to control the functions of the electro-mechanical surgical system **510** and the device attached to the flexible shaft **520**.

As described hereinabove, the front panel **515** of housing **514** includes display device **516** and indicators **518*a***, **518*b***. The display device **516** may include an alpha-numeric display device, such as an LCD display device. Display device **516** may also include an audio output device, such as a speaker, a buzzer, etc. The display device **516** is operated and controlled by controller **1122** in accordance with the operating program or algorithm corresponding to the device attached to the flexible shaft **520** (e.g., the surgical device **11**). If no surgical instrument or attachment is so attached, a default operating program or algorithm may be read or selected by, or transmitted to, controller **1122** to thereby control the operation of the display device **516** as well as the other aspects and functions of the electro-mechanical surgical system **510**. If surgical device **11** is attached to flexible shaft **520**, display device **516** may display, for example, data indicative of the gap between lower jaw **50** and upper jaw **80** as determined in accordance with the output signal of encoders **1106**, **1108**, as more fully described hereinabove.

Similarly, the indicators **518*a***, **518*b*** are operated and controlled by controller **1122** in accordance with the operating program or algorithm corresponding to the device **11**, attached to the flexible shaft **520** (e.g., the surgical device **11**). Indicator **518*a*** and/or indicator **518*b*** may include an audio output device, such as a speaker, a buzzer, etc., and/or a visual indicator device, such as an LED, a lamp, a light, etc. If the surgical device **11** is attached to the flexible shaft **520**, indicator **518***a* may indicate, for example, that the electro-mechanical surgical system **510** is in a power ON state, and indicator **518***b* may, for example, indicate whether the gap between lower jaw **50** and upper jaw **80** is determined to be within the acceptable range as more fully described hereinabove. It should be appreciated that although only two indicators **518***a*, **518***b* are described, any number of additional indicators may be provided as necessary. Additionally, it should be appreciated that although a single display device **516** is described, any number of additional display devices may be provided as necessary.

The display device **516**' and indicators **518***a*', **518***b*' of wired RCU **1150** and the display device **516**" and indicators **518***a*", **518***b*" of wireless RCU **1148** are similarly operated and controlled by respective controller **1322**, **1322** in accordance with the operating program or algorithm of the device attached to the flexible shaft **520**.

As previously mentioned, the surgical device **11** may be employed to clamp, cut and staple a section of tissue. The operation of the surgical device **11** will now be described in connection with the removal of a cancerous or anomalous section of tissue in a patient's bowel, which is, of course, merely one type of tissue and one type of surgery that may be performed using the surgical device **11**. Generally, in operation, after cancerous or anomalous tissue has been located in the gastrointestinal tract, the patient's abdomen is initially opened to expose the bowel. Utilizing the remote actuation provided by the electro-mechanical surgical system **510**, the upper and lower jaws **50**, **80** of the surgical device **11** are driven into the open position. The tube of the bowel is then placed on a side adjacent to the cancerous tissue between the spread jaws. Again, by remote actuation, the second driver is caused to engage in reverse, and the upper jaw closes onto the bowel and the lower jaw. Once the bowel has been sufficiently clamped, the first driver is engaged, which causes the wedge to advance simultaneously from the distal end of the attachment to the proximal end thereof, thereby cutting and stapling the bowel. This step is then repeated on the other side of the cancerous tissue, thereby removing the section of bowel containing the cancerous tissue, which is stapled on either end to prevent spilling of bowel material into the open abdomen.

More specifically, according to the example embodiment of the present invention, the surgical device **11** is coupled to the attachment socket or coupling **26** of the electro-mechanical driver component **510** such that the upper drive socket **180** engages the corresponding flexible drive shaft **530** of the electro-mechanical driver component **510** and the second drive socket **310** engages the corresponding flexible drive shaft **532** of the electro-mechanical driver component **510**. Thus, rotation of the upper horizontal shaft **151** is effected by rotation of the upper drive socket **180** which is effected by rotation of the corresponding flexible drive shaft **530** of the electro-mechanical driver component **510**. Clockwise or counter-clockwise rotation is achieved depending on the direction of the motor **580**. Similarly, rotation of the lower horizontal shaft **260** is effected by rotation of the second drive socket **310** which is effected by rotation of the corresponding flexible drive shaft **532** of the electro-mechanical driver component **510**. Again, clockwise or counter-clockwise rotation is achieved depending on the direction of the motor **576**.

In order to clamp the exposed ends of the bowel, the upper motor **580** corresponding to the upper flexible drive shaft **530** is activated, which engages the upper drive socket **180** at the proximal end **170** of the upper horizontal shaft **151**, thereby causing the upper horizontal shaft **151** to turn in a first (e.g., clockwise) rotation. When the surgical device **11** is in an initial closed state as illustrated in FIG. **5**, this first rotation of the upper horizontal shaft **151** causes the outer threads **152** of the upper horizontal shaft **151** to engage the outer threads **132** of the vertical shafts **130**, thereby causing the vertical shafts **130** to turn in a similar first (e.g., clockwise) rotation. This rotation of the vertical shafts **130** causes the outer threads **132** of the vertical shafts **130** to channel within the inner threads **92** of the vertical bores **90**, thereby causing the upper jaw **80** to rise in a continuous fashion (in the embodiment illustrated, in a parallel alignment with the fixed lower jaw **50**) and begin separating from the lower jaw **50**. Continuous operation of the motor in this manner eventually places the surgical device **11** in an open state, providing a space between the upper jaw **80** and the lower jaw **50**, as illustrated in FIG. **6**.

Once the surgical device **11** is in this open state, the tray **220** of staples **230** may be accessible, and may be inspected to determine whether the staples **230** are ready for the procedure and/or replace the tray **220** with a more suitable tray **220**. In addition, the status of the surgical device **11** may be determined by the control system **1122** as described hereinabove. Once the tray **220** is determined to be ready and in place, a section of the colon is placed between the upper jaw **80** and lower jaw **50**. Thereafter, the upper motor **580** is reversed to effect a second (e.g., counter-clockwise) rotation of the upper horizontal shaft **151**, which in turn effects counter-clockwise rotation of the vertical shafts **130**, which in turn effects a lowering of the upper jaw **80**. Continuous operation of the upper motor **580** in this manner eventually returns the linear clamping and stapling device to a dosed state, in which the distal end of the bowel is clamped between the upper jaw **80** and the lower jaw **40**.

The clamping of the distal end of the bowel is determined in accordance with the output sensors **1246** and **1248** or output electrodes **182**, **184** as described above. Circuit components in the electro-mechanical surgical system **510** may provide an alert to signal that it is safe and/or appropriate to begin the cutting and stapling procedure. To begin the stapling and cutting procedure, the lower motor **576** of the electro-mechanical driver component corresponding to the lower flexible drive shaft **532** is activated, which engages the lower drive socket **310** at the proximal end **300** of the lower horizontal shaft **260**, thereby causing the lower horizontal shaft **260** to turn in a first (e.g., counter-clockwise) rotation. When the stapling and cutting mechanism is in an initial loaded state, the wedge **270** and the blade **51** associated therewith are in the channel **250** at a position farthest from the proximal end **300** of the lower horizontal shaft **260** (i.e., at the distal end). The counter-clockwise rotation of the lower horizontal shaft **260** causes the outer threads **262** of the lower horizontal shaft **260** to engage the inner threads **292** of the horizontal threaded bore **290** of the wedge **270**, thereby causing the wedge **270** to travel through the channel **250** in a proximal direction toward the proximal end **300** of the lower horizontal shaft **260**. Continuous operation of the lower motor **576** in this manner will move the wedge **270** fully through the channel **250**. As the wedge **270** moves through proximally the channel, the blade **51** mounted to the top of the wedge cuts through the bowel, thereby transecting it. Simultaneously, the sloped top face **280** of the wedge **270** contacts the butts **232** of the staples **230**, thereby pushing the prongs **234** of the staples **230** through the tissue of the clamped distal end of bowel and against the staple guides **240**, which bends and closes the staples **230**. When the wedge **270** is moved proximally fully through the channel **250**, all of the staples **230** are pushed through the tray

220 and closed, thereby stapling closed the distal end of the bowel on both sides of the cut.

Thereafter, the upper motor **580** is again activated to effect a clockwise rotation of the upper horizontal shaft **151**, which in turn effects a clockwise rotation of the vertical shafts **130**, which in turn effects a raising of the upper jaw **80**. Continuous operation of the upper motor **580** in this manner eventually returns the surgical device **11** into the open state. Thereafter, the empty tray **220** is replaced with a full tray **220** and the same clamping, cutting and stapling procedure is performed on the proximal end of the bowel. It should be understood that prior to the secure clamping, cutting and stapling procedure, the blade **51** and the wedge **270** may be returned to the distal position by operation of the lower motor **576**. In order to accomplish this, the lower motor **576** is reversed to effect a clockwise rotation of the lower horizontal shaft **260**, which in turn moves the wedge **270** away from the proximal end **300** of the lower horizontal shaft **260**. Continuous operation of the lower motor **576** in this manner eventually returns the wedge **270** to its initial position at the distal end of the mechanism. Once the proximal end of the bowel is also clamped, cut and stapled, the attachment (i.e., the surgical device **11**) may be separated from the electro-mechanical driver component and discard the attachment.

As previously mentioned, FIGS. **31** to **33** illustrate an alternative example embodiment, wherein the surgical device **11** includes a blade **651** rotatably coupled to a wedge **670** so as to rotate between a first and a second position. The steps performed in order to operate this alternative example embodiment of the surgical device **11** are substantially similar to the steps described above as performed in order to operate the example embodiment of the surgical device **11** illustrated in FIGS. **5** and **6**. The operation of those additional features of the surgical device **11** of the alternative example embodiment illustrated in FIGS. **31** to **33** will now be described. Referring to FIG. **31**, and as previously discussed, the wedge **270** is illustrated as being located at the distal end of the lower jaw **50** after the clamping operation has been performed but before the cutting and stapling operation has begun. The blade **651** is rotatably mounted to the wedge **270** by pivot member **652**. The cutting edge **651***a* of the blade **651** is initially disposed in a retracted or down position, e.g., facing lower horizontal shaft **260**. The tail region **654** of the blade **651** is disposed above the wedge **270**, so that the actuating pin receiving face **653** initially faces the proximal end **170** of the surgical device **11** and is adjacent to fixed actuating pin **655** of lower jaw **50**.

FIG. **32** illustrates the surgical device **11** in which the cutting and stapling operation has begun, e.g., by rotating horizontal shaft **260** so as to begin moving the wedge **270** from the distal end of the lower jaw **50** toward the proximal end of the lower jaw **50**. As illustrated in FIG. **32**, the actuating pin receiving face **653** located at the tail region **654** of blade **651** engages fixed actuating pin **655**, causing the blade **651** to rotate relative to the wedge **270** around pivot member **652**. By rotating relative to the wedge **270** around pivot member **652**, the cutting edge **651***a* of the blade **651** is displaced from its initial position facing the lower horizontal shaft **260** and begins to swing upwardly.

FIG. **33** illustrates the surgical device **11** in which the cutting and stapling operation has continued further, e.g., by further rotating horizontal shaft **260** so as to continue to move the wedge **270** from the distal end of the lower jaw **50** toward the proximal end of the lower jaw **50**. As illustrated in FIG. **33**, the wedge **270** has moved proximally far enough toward the proximal end of the lower jaw **50** so as to cause actuating pin receiving face **653** at the tail region **654** of blade **651** to complete its engagement with fixed actuating pin **655**. At this point, the blade **651** is rotated relative to the wedge **270** around pivot member **652** such that the cutting edge **651***a* of the blade **651** faces the proximal end of the lower jaw **50**.

As previously mentioned, one problem of conventional cutting and stapling devices is that the opposing jaws of the mechanism tend to open, or be urged apart, during operation. This follows because the force exerted by the sloped top face **280** of wedge **270** has an upward component when sloped face **280** contacts the butt **232** of the staples **230** in the staple tray **220** and urges the prongs **234** of the staples **230** into the opposing staple guides **240**. As prongs **234** contact guides **240**, the force of the contact tends to separate, or urge apart, the upper and lower jaws until the prongs **234** of the staples are bent by guides **240** into a closed position. If the upper and lower jaws separate by a sufficient distance, the prongs **234** will not be sufficiently bent by guides **240** into the dosed position, and the inadequately stapled end of the tissue may permit its contents to spill into the open abdomen of the patient, increasing the likelihood of infection and other complications.

In accordance with the example embodiment of the present invention, movement of the cutting and stapling element, e.g., the wedge **270** and blade **51**, from the distal end of the surgical device **11** to the proximal end during the cutting and stapling operation may reduce the tendency of the upper and lower jaws to separate, or to be urged apart, during the cutting and stapling operation. Specifically, by moving the cutting and stapling element, e.g., the wedge **270** and the blade **51**, from the distal end of the surgical device **11** to the proximal end during the cutting and stapling operation, there may be a resulting reduction in the distance between the upper and lower jaws at its distal end. For instance, in linear clamping, cutting and stapling devices in which a wedge/blade is moved from the proximal end to the distal end during the stapling and cutting operation, the first staple encountered by the wedge is the staple that is located closest to the proximal end. When the wedge contacts the butt of this first staple, the wedge forces the prongs of the staple into contact with the opposing staple guide in the upper jaw. Until the prongs have been bent and closed, this contact between the prongs of the staple and the opposing staple guide causes the distance between the upper and lower jaws, at the proximal end thereof, to increase by a small amount. However, because the upper and lower jaws are mechanically, e.g., pivotably, connected at the proximal end but are free at the distal end, the small increase in the distance between the upper and lower jaws at the proximal end translates into a relatively large increase in the distance between the upper and lower jaws at the distal end. Simultaneously, while the blade is cutting the tissue clamped between the upper and lower jaws, the distal movement of the blade also tends to push the tissue clamped between the upper and lower jaws toward the distal end of the jaws. Because the jaws have been forced apart at their distal end, a greater amount (i.e., thickness) of tissue may be accommodated at the distal end of the jaws, and the pushing action of the blade against the tissue tends to push, the greater amount of tissue into the space at the distal end of the jaws. Once the additional tissue is accommodated between the distal ends of the upper and lower jaws, the tissue further acts to force the distal ends of the jaws apart. Thus, when the cutting and stapling element has traveled to the distal end of the jaws, the distance between the jaws at the distal end may be undesirably large, and effective stapling of the tissue between the distal ends of the jaws may be less than optimal.

By contrast, in accordance with the example embodiment of the present invention, the first staple **230** encountered by the wedge **270** is the staple which is located closest to the distal end of the lower jaw **50**. When the wedge **270** contacts the butt **232** of this first staple, the wedge **270** forces the prongs **234** of the staple **230** into contact with the opposing staple guide **240** in the upper jaw **80**. This contact between the prongs **234** of the staple **230** and the opposing staple guide **240** may cause the distance between the upper jaw **80** and the lower jaw **50** at the distal ends thereof, to increase by a small amount, because the upper jaw **80** and lower jaw **50** are free at their distal end. However, because the upper jaw **80** and lower jaw **50** are mechanically connected at their proximal ends, the small increase in the distance between the upper jaw **80** and lower jaw **50** at their distal end does not translate into a corresponding large increase in the distance between the upper jaw **80** and lower jaw **50** at their proximal ends. Furthermore, in the example embodiment of the present invention, while the blade **51** is cutting the tissue clamped between the upper jaw **50** and lower jaw **80**, the horizontal movement of the blade **51** tends to push the tissue clamped between the upper jaw **80** and lower jaw **50** towards the proximal end of the jaws. However, because the upper jaw **80** and lower jaw **50** have not been forced apart at their proximal ends, a greater amount (i.e., thickness) of tissue may not be accommodated at the proximal ends of the jaws, and the cutting force of the blade **51** against the tissue may not tend to push a greater amount of tissue into the space at the proximal end of the jaws. Thus, since no additional tissue may be accommodated between the proximal ends of the upper jaw **80** and the lower jaw **50**, the tissue may not further act to force the proximal ends of the jaws apart. Thus, by the time the cutting and stapling element, e.g., the blade **51** and the wedge **270**, has traveled to the proximal end of the lower jaw **50**, the distance between the lower jaw **50** and the upper jaw **80** at the proximal end may remain substantially unchanged, thereby insuring optimal effectiveness for stapling of the tissue between the proximal ends of the lower and upper jaws **50**, **80**. Also, when the wedge **270** eventually contacts the staples **230** at the proximal end of the jaws **50**, **80**, the distance between the upper and lower jaws **50**, **80**, at their proximal end may increase by a small amount. However, since the tissue located at the distal end has already been cut and stapled, any larger distance between the upper jaw **80** and the lower jaw **50** at the distal end at this time is irrelevant. Thus, the present invention insures optimal effectiveness of stapling by reducing the tendency of the upper and lower jaws to separate during operation.

The example embodiment of the present invention may also reduce the torque which is required to move the wedge **270** and may therefore reduce the stress which is experienced by various components of the surgical device. For instance, in linear clamping, cutting and stapling devices, which move a wedge/blade from the proximal end to the distal end, the torque that is required to move the wedge/blade increases as the wedge/blade moves from the proximal end to the distal end, because the distance between the wedge/blade and the proximal end of the device (the point at which the rotatable drive shaft is coupled to the device) increases. In addition, the torque that is required to move the wedge/blade also increases as the wedge/blade moves from the proximal end to the distal end, because of the additional tissue accommodated at the distal end of the device. As discussed above, while the blade is cutting the tissue clamped between the upper and lower jaws, the distal movement of the blade also tends to push the tissue clamped between the upper and lower jaws towards the distal end of the jaws. In order to cut through the greater amount (i.e., thickness) of tissue accommodated at the distal end of the jaws, a greater amount of torque is required to be imparted by the horizontal drive shaft to the wedge/blade. Thus, when the cutting and stapling element has traveled to the distal end of the jaws, the torque has increased, thereby causing stress in the wedge/blade, and drive mechanisms of the device.

In contrast, in accordance with the example embodiment of the present invention, there may be a reduction in the torque that is required to move the wedge **270** during the cutting and stapling operation, thereby reducing the stress that is experienced by various components of the surgical device **11**. For instance, in surgical device **11**, which moves the wedge **270** and blade **51** from the distal end to the proximal end of the lower jaw **50**, the torque that is required to move the wedge **270** and the blade **51** decreases as the wedge **270** and the blade **51** move from the distal end to the proximal end of lower jaw **50** because the distance between the wedge/blade and the proximal end of the device (the point at which the rotatable drive shaft is coupled to the device) decreases. In addition, the torque that is required to move the wedge/blade also decreases as the wedge/blade moves from the distal end of lower jaw **50** to the distal end, because there is no additional tissue accommodated at the proximal end of the jaws **50** and **80**. Unlike conventional linear clamping, cutting and stapling devices, while the blade **51** of the surgical device **11** is cutting the tissue clamped between the upper jaw **80** and the lower jaw **50**, the proximal movement of the blade **51** does not tend to push the tissue clamped between the upper jaw **80** and the lower jaw **50** toward the proximal end of the jaws. Thus, since the blade **51** is not required to cut through a greater amount (i.e., thickness) of tissue accommodated at the proximal end of the jaws, a greater amount of torque is not required to be imparted by the lower horizontal shaft **260** to the wedge **270** and the blade **51** in order to cut the tissue. When the wedge **270** and the blade **51** have traveled to the proximal end of the lower jaw **50**, the torque has decreased, thereby reducing the stress in the wedge **270**, blade **51**, first driver **261**, etc.

The example embodiment of the present invention may also reduce the length of a linear clamping, cutting and stapling device, thereby improving the device's ability to be employed in small spaces. Because a linear clamping, cutting and stapling device may be intended to be employed corporeally, e.g., inside the body of a patient, the device must be small enough to be maneuvered inside the body of the patient. In conventional linear clamping, cutting and stapling devices, which move a wedge/blade from the proximal end to the distal end, the space that is required in order to house the wedge/blade at the proximal end of the device increases the overall length of the device. This increase in the length of the device makes the device more difficult to maneuver inside the patient's body.

In contrast, in accordance with the example embodiment of the present invention, the surgical device **11** initially houses wedge **270** and blade **51** at the distal end of lower jaw **50**, which is unencumbered by the memory unit **1174**, vertical drive shafts **130**, and various other components that are located at the proximal end of surgical device **11**. Thus, by initially disposing the wedge **270** and the blade **51** at the distal end of lower jaw **50**, and by moving the wedge **270** and the blade **51** from the distal end of lower jaw **50** to the proximal end, the overall length of surgical device **11** relative to conventional linear clamping, cutting and stapling devices may be reduced. This decrease in overall length makes the surgical device **11** easier to maneuver inside the patient's body, as compared to conventional linear clamping, cutting and stapling devices.

By decreasing the required overall length of surgical device **11** relative to conventional linear clamping, cutting and stapling devices, according to an example embodiment, the surgical device **11** may also provide a corresponding increase (approximately 30%) in the length of its stroke, e.g., the distance which the wedge **270** and the blade **51** may travel during the cutting and stapling operation, as compared to conventional linear clamping, cutting and stapling devices. For instance, since the overall length of surgical device **11** may be reduced (relative to the overall length of conventional linear clamping, cutting and stapling devices) due to the space saved by initially positioning the wedge **270** and the blade **51** at the distal end, the saved space may also increase the stroke length of the surgical device **11**. Thus, the surgical device **11** may be configured, according to one example embodiment, to clamp, cut and staple larger sections of tissue than conventional linear clamping, cutting and stapling devices.

The example embodiment illustrated in FIGS. **31** to **33** may also improve the safety of the surgical device **11** in that the cutting edge **651***a* of the blade **651** is retracted, e.g., not exposed, when the wedge **270** is in an initial position at the distal end of lower jaw **50**. Specifically, according to this example embodiment, during the stage of the operation when the section of tissue to be clamped, cut and stapled is placed and clamped between upper jaw **80** and lower jaw **50** of the surgical device **11**, the cutting edge **651***a* of the blade **651** is retracted. By retracting the cutting edge **651***a* of the blade **651** during this positioning and clamping stage of the operation, the likelihood that the section of tissue will be inadvertently cut before the section of tissue is adequately clamped may be decreased. Furthermore, accidental cutting by blade **651** of, for example, an operator or other equipment, may be reduced by the arrangement of the retracted blade **651**. According to the example embodiment, only after the section of tissue has been clamped (and it has been determined that it is appropriate to start the cutting and clamping stage of the operation) is the wedge **270** moved toward the proximal end of the lower jaw **50**, thereby causing the cutting edge **651***a* of the blade **651** to be disposed in a cutting position, e.g., facing the proximal end of lower jaw **50**.

Thus, the several aforementioned objects and advantages of the present invention are most effectively attained. Those skilled in the art will appreciate that numerous modifications of the exemplary embodiment described hereinabove may be made without departing from the spirit and scope of the invention. Although a single exemplary embodiment of the present invention has been described and disclosed in detail herein, it should be understood that this invention is in no sense limited thereby.

What is claimed is:

1. A surgical device, comprising:
- a first jaw defining a longitudinal axis;
- a second jaw mechanically coupled in opposed relation to the first jaw;
- a cutting element disposed within and rotatable relative to the second jaw; and
- a wedge coupled to the cutting element, the wedge disposed within the second jaw.

2. The surgical device according to claim **1**, wherein the wedge is coupled to the cutting element via a pivot member.

3. The surgical device according to claim **2**, wherein the wedge is seated in a wedge guide channel formed in the second jaw.

4. The surgical device according to claim **3**, wherein
- an upper horizontal shaft is coupled to a proximal end of the first jaw; and
- a lower horizontal shaft extends through the second jaw, the upper and lower horizontal shafts configured to be parallel to each other at a fixed distance.

5. The surgical device according to claim **4**, wherein the proximal end of the first jaw includes a pair of threaded vertical bores through which extend a corresponding pair of vertical shafts.

6. The surgical device according to claim **5**, wherein the pair of vertical shafts engage the upper horizontal shaft.

7. The surgical device according to claim **6**, wherein the cutting element includes a cutting edge initially disposed in a retracted position where the cutting edge faces the lower horizontal shaft.

8. The surgical device according to claim **7**, wherein the cutting element includes a tail region having an actuating pin receiving face initially facing a proximal end of the surgical device.

9. The surgical device according to claim **8**, wherein a fixed actuating pin is disposed adjacent the actuating pin receiving face, the fixed actuating pin attached to the first jaw.

10. The surgical device according to claim **9**, wherein, when the lower horizontal shaft is rotated, the wedge is moved from a distal end to the proximal end of the first jaw.

11. The surgical device according to claim **10**, wherein, when the lower horizontal shaft is further rotated, the actuating pin receiving face of the tail region of the cutting element engages the fixed actuating pin and causes the cutting element to rotate relative to the wedge around the pivot member.

12. The surgical device according to claim **11**, wherein, when the lower horizontal shaft is further rotated, the cutting edge of the cutting element faces the proximal end of the first jaw.

13. The surgical device according to claim **12**, further comprising:
- a first rotatable shaft rotatable about the longitudinal axis of the first jaw, the first rotatable shaft coupled to the first jaw and adapted to cause the first jaw to travel linearly in a direction perpendicular to the longitudinal axis while maintaining parallel correspondence between the first and second jaws; and
- a second rotatable shaft being in turning and gearing relationship with the cutting element.

14. The surgical device according to claim **13**, further comprising:
- a first motor for driving the upper horizontal shaft; and
- a second motor for driving the lower horizontal shaft.

15. An electro-mechanical surgical system, comprising:
- an elongated shaft;
- a first axially rotatable drive shaft disposed within the elongated shaft;
- a surgical device configured to detachably couple to a distal end of the elongated shaft, wherein the surgical device includes:
  - a first jaw defining a longitudinal axis;
  - a second jaw mechanically coupled in opposed relation to the first jaw;
  - a cutting element disposed within and rotatable relative to the second jaw; and
  - a wedge coupled to the cutting element, the wedge disposed within the second jaw.

16. The surgical device according to claim **15**, wherein the wedge is coupled to the cutting element via a pivot member and is seated in a wedge guide channel formed in the second jaw.

17. The surgical device according to claim **16**, wherein
- an upper horizontal shaft is coupled to a proximal end of the first jaw; and
- a lower horizontal shaft extends through the second jaw, the upper and lower horizontal shafts configured to be parallel to each other at a fixed distance.

18. The surgical device according to claim **17**, wherein the proximal end of the first jaw includes a pair of threaded vertical bores through which extend a corresponding pair of vertical shafts, the pair of vertical shafts engaging the upper horizontal shaft.

19. The surgical device according to claim **18**, wherein the cutting element includes:

a cutting edge initially disposed in a retracted position where the cutting edge faces the lower horizontal shaft; and

a tail region having an actuating pin receiving face initially facing a proximal end of the surgical device.

20. The surgical device according to claim **19**, wherein

a fixed actuating pin is disposed adjacent the actuating pin receiving face, the fixed actuating pin attached to the first jaw; and

when the lower horizontal shaft is rotated,

(i) the wedge is moved from a distal end to the proximal end of the first jaw; and

(ii) the actuating pin receiving face of the tail region of the cutting element engages the fixed actuating pin and causes the cutting element to rotate relative to the wedge around the pivot member.

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